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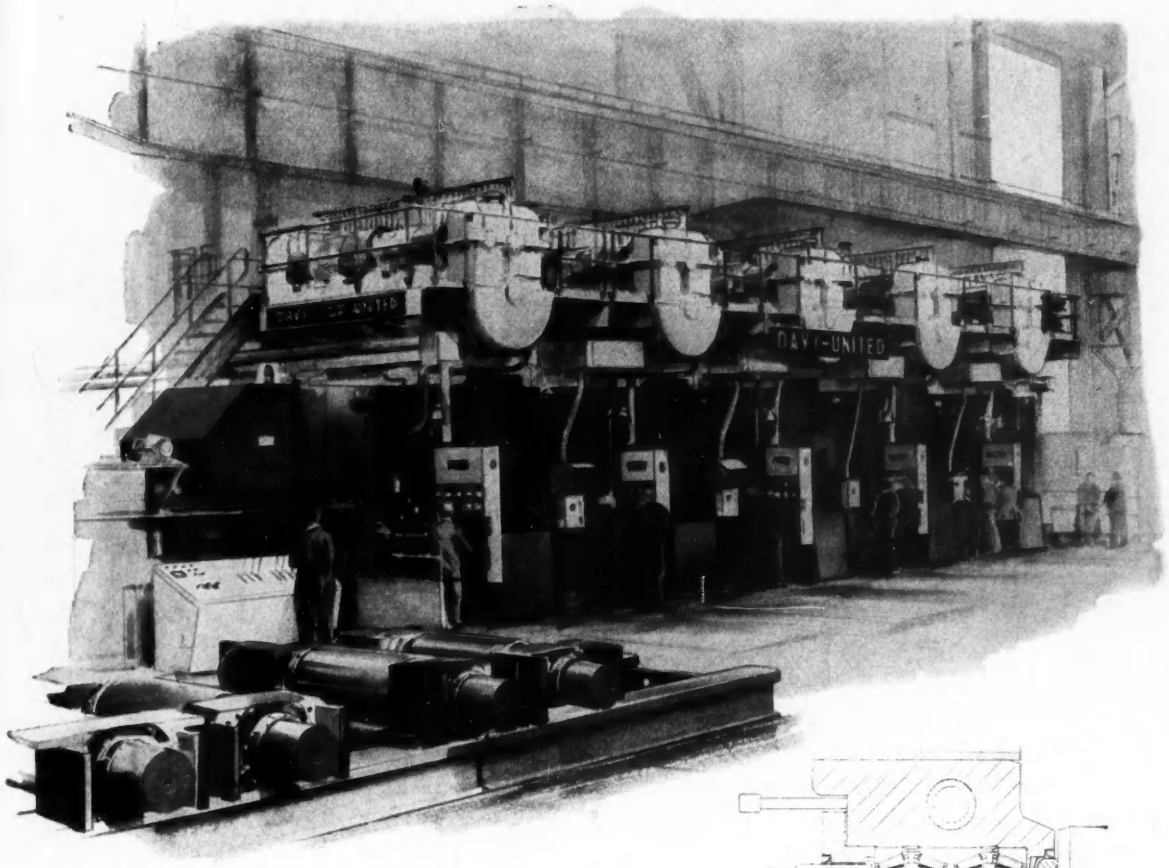

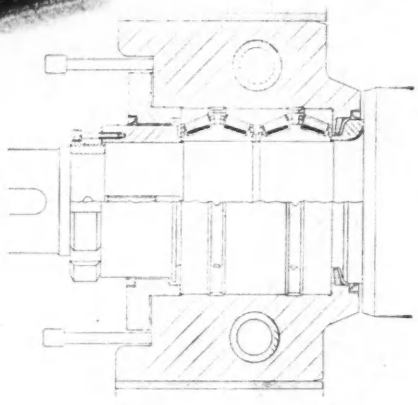

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December 10–11	Miscellaneous stores	M.O.S. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
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SCIENCE AND INTERNATIONALISM

One of the more valuable qualities of science is related only indirectly with the discoveries made through the use of its methods. Science is international ; it has advanced rapidly because it has recognised no international frontiers. It has therefore the valuable quality of drawing together into beneficent inquiry men of all nations ; jealous nationalism and secrecy are abhorrent to it. The arts, of course, have, in large degree, a similar quality ; but there can still be nationalism in art. The artists of one country have sometimes proved capable of holding the work of artists in another decadent and worthless. But though a novel hypothesis formulated in one country may at first be held elsewhere to be untenable, experiment soon provides a yardstick by which its real worth may be assessed. There are few amongst eminent scientists, however advanced their ideas, whose worth has gone unrecognised outside their own countries even so far as middle-age. Indeed, great scientists, of whatever nation, tend to attract to their laboratories able men from all parts of the world. When, for example, Niels Bohr set up an Institute for Theoretical Physics in Copenhagen, it became a Mecca attracting scientists from the whole of Europe and indeed the world. This international cultural quality, especially notable in science, is peculiarly valuable in this present age. For it can be set off against that other quality of science—which more easily catches the layman's eye—of being responsible for discoveries which have led to the development of means of waging war more dreadful than man has ever known before.

It was this internationalism of science which formed the theme of an address delivered by Sir John Cockcroft before the Fondation Europeene de la Culture in Amsterdam last week-end. Back in the eighteenth century, he pointed out, European science still retained something of the universality of medieval learning. That universality has persisted to this day. In 1813, even though Britain and France were at war, Sir Humphry Davy, by the express permission of Napoleon, was able to visit Paris, taking Michael Faraday with him. The electrical units express succinctly how international were discoveries of the nineteenth century. The volt, the ampere, the ohm and the farad commemorate the work, respectively, of an Italian, a Frenchman, a German and an Englishman. The great names in other sciences similarly reflect their universality, Maxwell, Hertz, Marconi, Roentgen, Curie, Rutherford, Kapitza. When Kapitza was prevented from returning from Russia to Cambridge between the wars, Rutherford was not deterred by nationalism. He sent off to Moscow the whole equipment of Kapitza's laboratory. To-day, as in the past, not only do scientists found their work upon discoveries made anywhere in the world, they collaborate easily across national frontiers wherever there is advantage in so doing. Turin, Milan, Padua and Rome, for example, are at this time collaborating with Bristol in studying sub-atomic particles, the mesons which are, to quote Sir John, "so closely connected with the nuclear forces which now dominate our future." Such, almost informal, collaboration occurs in many fields. In others, scientists in a particular field, or national scientific bodies, have co-operated to set up international organisations. There is, for example, the European Atomic Energy Society, which has no funds, no publicity and no staff, and exists to promote informal discussion amongst scientists by organising symposia several times a year. Recently, no doubt because national governments have become increasingly aware of the importance for national prosperity of the development of science and technology, collaboration has become inter-governmental. To-day, indeed, that kind of collaboration has become essential in certain fields, because of the increase in the complexity and expense of many modern instruments of research. The lack of international jealousy amongst scientists is illustrated by one of Sir John's remarks upon this point. One of the potential difficulties in inter-governmental organisations, he said, is the danger that politics and national prestige will influence appointments. To scientists it matters not a whit what the nationality of the man who heads an organisation may be ; it is his ability that counts.

Sir John Cockcroft spoke predominantly of European contributions to scientific advancement. For, indeed, in the past it was predominantly in Europe that advances were made. Even to-day, when in certain fields of endeavour, the Americans and Russians can command special equipment not available in Europe, European traditions of scholarship, of care, of criticism and of hard thinking, hold for that continent the leading place in scientific research. However, as Sir John strongly emphasised, work upon the frontiers of nuclear physics can now be carried out only in the U.S.A. and Russia, with the inevitable result that there has been a migration of some of Europe's best physicists across the Atlantic. That elsewhere than in Europe traditions should be built up is much to be welcomed and very much to the good. For particularly in Russia and to some extent even in the U.S.A., too much

weight is still given to that security and secrecy believed to be in the narrow interest of the State, too little to the catholic spirit of universality which has contributed so much to the advancement of science and which has so much to preach to the world at large about the virtues of co-operation. But it would be a tragedy if the traditions built up in so many universities and laboratories in Europe were to be lost because special equipment was not forthcoming. Fortunately the danger has been seen. Sir John was able to mention the work of the European Council for Nuclear Research set up in Geneva in 1951 which has already in use a powerful machine for nuclear research under the leadership of a German and an Italian physicist. A second machine to produce 25 billion volts, designed and built by scientists, engineers and technicians drawn from twelve European countries, will come into use in 1960. Such collaboration is essential for the advancement of science. Far may it extend ! For, in this age of hydrogen bombs and inter-continental ballistic missiles, it is obvious that the nations of the world will benefit more from such fruitful collaboration, extending, we hope, to more and more fields of human endeavour than from a resort to narrow and selfish nationalism.

COMPETITIVE TENDERING

Apart from those engineering organisations which offer relatively standardised products for sale, probably the great bulk of the engineering industry obtains its work by tendering. Prices must be keen or the work will go elsewhere ; hence the stimulus of competition, so universally valued and practised everywhere, even in the U.S.S.R. Only consulting engineers, and some others engaged in similar work, are considered to be sufficiently impeccable to be left permanently outside the influence of this stimulus, and yet remain financially virtuous ! The competitive tender is, in fact, a widespread and commonly accepted safeguard. But whether it does actually achieve economy on a national scale has been questioned. Sir George Nelson, in his recent presidential address before the Institution of Mechanical Engineers, was emphatic on this point. " All my life," he said, " it has been a nightmare to me that firms such as mine are constantly submitting tenders which may cost as much as £20,000 to £30,000 to assemble, of which only 10 per cent result in orders. The waste involved in the 90 per cent of unsuccessful tenders throughout the whole of our great engineering industry is colossal. It is bad enough in terms of money, but far worse than this is the effect in terms of technical manpower. . . . It is incumbent upon members of this Institution, and indeed all professional engineers, to see that this problem is thoroughly and objectively studied. It is largely a matter of confidence to ensure that there is no question of exploitation involved, but to provide means whereby the purchaser and supplier can work out the most efficient, cheapest and satisfactory way of doing the work without involving a waste of technical effort. I feel that this problem of excessive competition for the sake of competition is the greatest factor in the waste of technical manpower."

It is doubtful whether the preparation of tenders for civil engineering work involves sums quite so large as those Sir George quotes, but the general tenor of his views could undoubtedly be referred to civil engineering contracts as well. At the highway conference held earlier this month at the " Civils," Mr. H. J. B. Harding expressed a very similar point of view, and criticised also the practice of duplicating engineering staff—on the consultants' and the contractors' organisations—who sometimes worked to promote friction rather than co-operation ; this duplication, he pointed out, was not paralleled in any other industry. Mr. Harding suggested, in his paper to the conference, methods whereby wasteful tendering could be reduced. " If a contractor has only a one-in-fifteen chance of obtaining a contract his decisions in tendering are affected and in general a great waste in man-hours is caused to a number of firms. These man-hours must be paid for, so they are carried to overheads and eventually become spread over other tenders. Thus, the economies which are expected by inviting a large number of competitors are somewhat illusory from the general view of the country's economy. It is ' productivity ' wasted. Five or six competitors will provide ample competition. These suggestions may not be very well received, for it is a common reaction to fear that contractors may make undue profits at the expense of the community and sometimes expense is incurred in merely trying to avoid such a contingency. The contractors on the whole are not quite so rapacious as some believe and being human often repay trust with trust."

Competitive tendering, however, also has its champions. Its value was stressed by Sir Arthur Whitaker in his presidential address at the Institution of Civil Engineers (also given this month). He pointed out that wartime conditions had been responsible for a loosening of method, and went on " The return to normality has not yet been attained and may take many years yet, but I believe that in the end competitive tendering will win the day to the exclusion of other methods of deciding contracts. If my belief is correct, and I have good grounds for thinking it is, it will be essential that schemes should be worked up fully before tendering is undertaken, and that the requirements to be fulfilled and the risks to be taken are defined as closely as can be. It is a failure to do this, whether from undue haste in undertaking a project or from inadequate preparation on the part of the engineers, that has enhanced the attractions of the contract placed on a target basis. I have some sympathy for this type of contract. Yet in my opinion the greatest efficiency is attained when open competition prevails."

How very awkward ! All we can think of, to add, is a very trite remark. There are two sides to every question. But here it hardly seems possible that both can be right.

FORTY HOURS

Last week the Engineering and Allied Employers' National Federation told the Confederation of Shipbuilding and Engineering Unions that it was unable to concede the claim for a reduction of the working week to forty hours without loss of pay. It is a decision that was expected. Furthermore, it is a decision that is right, for the Employers' Federation knows well that a shorter working week could only result in increased wages costs which it would be perilous for the engineering industry to incur in the present state of the national economy. We suspect that the union leaders, although naturally expressing disappointment over the reply, are just as well aware as the employers that the rejection of the demand is not unreasonable. When the claim for a forty-hour week was formulated last June, the unions declared quite firmly that it was in no way influenced by the wage agreement which had then just been reached. A forty-hour week, they asserted, was a natural consequence of the increasing introduction of automation in the engineering industry. There is, of course, a great deal of substance in the argument that, as technical progress leads to more efficient production methods, a bigger output can be expected in fewer hours of work each week. But with the present statutory week of forty-four hours in the engineering industry, the average hours actually being worked are just under forty-eight. That is an average which, as the Employers' Federation has pointed out, has changed very little for several years. The increase in productivity and output which has been seen in the post-war years has come almost entirely from improved techniques ; workers in the engineering industry have shared the financial benefits of that improvement. Yet there has been no real reduction in the number of hours worked. In these circumstances, it has been estimated, a statutory week of forty hours would mean an addition of £65,000,000 to the engineering industry's annual wages bill. An additional charge of that magnitude could certainly not be faced in our existing economic climate.

A Seven Day Journal

Nuclear Power Stations for Italy

It has been announced that the AGIP Nucleare, a subsidiary of Ente Nazionale Idrocarburi, Rome, has reached an agreement with the Nuclear Power Plant Company, Ltd., with respect to the construction of nuclear power stations in Italy. The first station is planned to have an output of 200MW. Its design and commissioning are to be the responsibility of the British consortium, but AGIP Nucleare is to place the local contracts and undertake erection on the site.

The agreement has been concluded in the form of a letter of intent to negotiate, sent to the consortium by the president of E.N.I. The subjects of negotiation include not only the construction of nuclear power stations, but also a long term arrangement for collaboration in the design and development of gas-cooled power reactors. Both parties have enjoyed the co-operation of the U.K. Atomic Energy Authority in their prior consultations. Although, during the first few years, the exchange of information will be mostly in one direction, it is hoped that the Italian contribution will increase as time goes on.

The single reactor for the first station is to have the same overall dimensions as each of the two reactors for the station now being constructed by the Nuclear Power Plant Company at Bradwell-on-Sea, Essex. The Bradwell reactors, it will be recalled, are guaranteed to produce 150MW apiece, and the increase in output promised for the Italian project is an index of the progress that has been made since the Bradwell design was accepted a year ago.

Report of H.M. Chief Inspector of Mines

THE Ministry of Power has published the report of H.M. Chief Inspector of Mines for the years, 1954, 1955 and 1956. The report is the last to be submitted under the Coal Mines Act of 1911; that Act, it will be recalled, has now been repealed with the coming into operation at the beginning of this year of the Mines and Quarries Act, 1954.

In the present report, the Chief Inspector understandably comments on the progress made in accident reduction in coal mines over the forty-five years during which the 1911 Act was effective. He points out that, in 1913, no less than 1753 persons were killed at mines coming within the scope of the Act, and that in 1956, the comparable number of fatalities was 330. Admittedly, the report says, the coal mining labour force is now smaller, but the fatality rates per 1000 people employed make an equally striking comparison, being 1·55 in 1913 and 0·45 in 1956. The number of persons killed in 1956, the report continues, was by far the lowest ever recorded. The average of fatalities for the three years reviewed was 375·3, compared with an average of 433 for the three preceding years. The report shows that there has also been a remarkable reduction in the number of persons injured in "immediately reportable" accidents. The average for the three years covered by the report was 1838, a figure which can be compared with 5675 injured in 1913.

In his comments, the Chief Inspector points out that major mining disasters always strike the headlines, and, unfortunately, he says, the risk of such a disaster is ever present in the complex circumstances in which mining operations are carried out. But, the report urges, it is important to remember that the majority of deaths and injuries in coal mines are caused by individual accidents. It is only by good practice, by constant vigilance and by the observance of statutory requirements and other well-established precautions that the risk of day-to-day accidents and major disasters can be minimised.

The Engineer

100 Years Ago

(NOVEMBER 27, 1857)

"AUSTRIAN STEEL MAKING"

"SIR,—Allow me just to contradict a statement made through the pages of your number dated November 13th. I see an account of the manufacture of steel in Austria, at the close of which paper there is a deliberate falsehood (nothing better), which I hereby refute. After the chairman asking some questions respecting Mr. Bessemer's process, which I care not to notice, a Mr. Hewett states that he *understood that Mr. Galloway, of Manchester, was finding capital for Mr. Bessemer* to manufacture *a kind of steel* suitable for *some* purposes. I am happy to be able to say, though in no way connected with Mr. Bessemer, I know this statement to be entirely false, and as to the kind of steel Mr. Bessemer is manufacturing that I leave for the article itself to vindicate, which it will doubtless shortly do; and perhaps Mr. Hewett will kindly state from what reliable source he derived his information on this subject, as I conceive a man should have good authority before making such statements. And I also think it would look better if our scientific men were a little more careful not to reduce their meetings to the level of an old woman's tea-table where scandal is freely talked.

A LOVER OF TRUTH"

"DYNAMIC POWER"

"SIR,—Your correspondent, W. Petrie, in his reply to 'Inventor,' states the following principle:—'The amount of *dynamic power* represented by a moving mass is not proportionate to the velocity, but to the square of the velocity.' I am at a loss to understand this law, and should feel much obliged if your correspondent would explain what he means by *dynamic power*.

Liége. W.G.B."

Train Accident Report for 1956

THE annual report to the Minister of Transport and Civil Aviation, dealing with the accidents which occurred on the railways in this country during 1956, shows that no passenger was killed in a train accident during the year. Of the eighteen fatalities, which were the result of seventeen train accidents, three of the killed were railway employees and thirteen of the remaining fifteen were occupants of road vehicles in level crossing collisions. The number of train accidents reported increased to 1226 (1156 the previous year), but there was again a reduction in the numbers of failures of permanent way, structures and rolling stock. As in the previous year, forty-nine passengers were killed, mainly as a result of misadventure, carelessness and misconduct, and some 4692 were injured for the same reasons.

An analysis of the primary causes of the 1226 train accidents reported shows that 640 were attributable to want of care or irregularities on the part of the operating staff, and it is pointed out that the numbers of accidents caused directly by human failure have risen fairly steadily since 1950. Errors on the part of train crews resulted in 238 collisions and derailments. The number of these train crew accidents as a result of disobeying signals has declined and a large number of the minor incidents concerned were the result of other irregularities or want of care. Technical defects of one kind or another, in many of which human failure had some part, decreased to 124 from 140 in 1955. The report concludes by pointing out that during 1956 more than 400 million train miles were run and more than 1500 million passengers were carried without the death of one in a train accident, whilst only three were seriously injured.

London's Traffic Problems

SPEAKING at the banquet of the City Livery Club on Wednesday evening of last week, Sir Brian Robertson, chairman of the British Transport Commission, expressed the opinion that over the next fifteen years peak hour traffic in the west end of London might increase by about a tenth, and in the city by about one-third. He said that despite all that was being done to improve public transport facilities into and within London, the traffic problem was bound to get progressively worse unless other drastic measures were enforced. The streets, Sir Brian went on, were made for movement and they must be cleared for movement; almost all remedies for congestion were highly unpopular, but the only way to get the biggest number of people into and out of the metropolis in the least discomfort was steadily to discourage the use of private transport, and to encourage the use of public transport by improving it, by giving it freedom to move and by staggering hours.

Outlining the anticipated rate of progress in improvements of London residential services by the increased use of electric and diesel traction and by other means, Sir Brian said that the recent cuts in capital investment were bound to have some effect upon these schemes. The investment cuts would involve, for example, some delay in the improvement of the Waterloo and City Railway. The problem, in a nutshell, Sir Brian stated, was that the total number of workers in the central area of London was about 1,250,000, of which 400,000 were in the city and 800,000 in the west end. Only about 100,000 of these lived in the central area which meant that over 1,000,000 had to be brought in every day from outside. The morning peak lasted from 8.45 to 9.45, and one-third of those who travelled by Underground to the city during the morning peak squashed themselves together in the quarter of an hour between 9 and 9.15; in the evening peak hour the position was rather worse. Similar telescoping of numbers took place on the bus services and on the railways. With the completion of new buildings and offices in the City of London, Sir Brian added, the final figure of employment was expected to be nearly 500,000, or 25 per cent more than at present. Within that total, the proportion of office workers would grow substantially while the numbers employed in warehouses and light industry would decrease. Moreover, the tendency for traffic to transfer from road to rail on account of increasing road congestion seemed likely to continue.

Nuclear Propulsion of Ships

By SIR CHRISTOPHER HINTON, K.B.E., M.A., F.R.S.,* and R. V. MOORE, G.C., B.Sc. (Eng.), M.I.Mech.E., M.I.E.E.†

This paper was presented last Wednesday before the Institution of Naval Architects. After briefly reviewing the historical background of power-driven ships and inferring some analogous future trends, the paper reviews the characteristics of pressurised water and gas-cooled, graphite-moderated reactors in general terms. The paper next describes a gas-cooled, graphite-moderated reactor of high rating designed for the propulsion of a super-tanker. The economics of operation of a nuclear-powered super-tanker are compared with one which is conventionally powered. Some of the practical problems, including control and safety, of a nuclear-powered ship are defined and discussed. The paper concludes with a review of some reactor types having potential merit for the marine application, and concludes that while nuclear power units of 20,000 to 25,000 s.h.p. with competitive economic performance could be designed in the next few years, a reactor suitable for powers below these values has yet to be developed.

IN a marine reactor it is important to achieve two design objectives, first, to reduce the weight per horsepower (and so capital cost) to a minimum, and, secondly, to minimise the fuel cost. In a nuclear reactor this is not just a question of reducing the U-235 consumption per brake horsepower-hour to the lowest possible value, but is also related to the initial concentration of the U-235 required to make the reactor operate, the amount of the new fuel plutonium formed and the burn-up of fissile atoms which can be achieved before replenishment of fuel is necessary.

To reduce the weight per horsepower as much heat as possible must be removed from a given volume of core, at the highest temperature. This implies small cores and high-temperature materials, giving rise to increased leakage and absorption of neutrons. To offset this, the production of neutrons must be increased by the use of enriched fuel which raises the fuel costs. We see, therefore, that for marine application the choice of reactor and its subsequent optimisation depends essentially on minimising the economic effect of falling weight per horsepower with rising fuel cost per horsepower-hour.

Nuclear Power Reactors which are Now Operational

The first nuclear reactors to be built either in America or in the United Kingdom were aimed primarily at the production of plutonium for defence purposes. The heat of fission was wasted because it was not possible to recover this heat at a temperature high enough to make it possible to convert it into mechanical or electrical energy. Such conversion of the heat of nuclear fission into electrical power on an industrial scale was first achieved in the reactors which were built at Calder Hall. These reactors, using graphite as a moderator and carbon dioxide gas under pressure as a coolant, have high weights per horsepower and were designed essentially for use in large land-based stations, where this is of no direct concern.

Meanwhile, however, an important advance in reducing the weight per horsepower had been made in the United States in developing the first nuclear submarine "Nautilus." The military advantages of using atomic energy for submarine propulsion are very great; the submarine is given a tremendous range of action and can develop full power for long periods when submerged. To secure such advantages it is necessary to use expensive equipment and expensive fuel which could not be justified in purely commercial applications. For the submarine it is, however, essential to obtain low weight per horsepower, compactness of plant and flexibility in operation at the expense of all else.

Assuming that the materials of construction make it possible to build a nuclear reactor which will give a reasonably high temperature in the heat cycle, the weight and size of the reactor will depend on the lattice spacing of the fuel elements in the core and on their specific rating. Specific rating is the rate at which heat can be extracted from the fuel elements in operation; obviously, if the specific rating is doubled, twice the amount of heat and, therefore, twice the amount of power, can be obtained from a reactor of a given size and weight.

For a given specific rating of the fuel elements the size of the reactor core will depend on the lattice pitch of the fuel elements: the pitch required in any moderator is determined by the ratio of moderator to fuel which is needed to slow the neutrons down to thermal velocities.

If graphite, heavy water or beryllium are used as moderators, the lattice pitch is likely to be of the order of 6in to a foot. But ordinary light hydrogen, although a wasteful moderator in that it absorbs more neutrons unprofitably than the others, is more effective in slowing neutrons down and, therefore, demands a smaller lattice pitch. When using hydrogen as a moderator in combination with oxygen as ordinary water, a lattice pitch of only an inch or two is needed and it follows, therefore, that a very compact core can be built. Water at sufficiently high velocity is also an effective coolant, making high ratings possible. For these reasons a reactor using water as a moderator and coolant is attractive for submarine propulsion and was selected by the Americans for this purpose.

Although with this type of reactor a low weight per horsepower can be achieved, due to the fact that water uselessly absorbs quite a high percentage of the available neutrons, fuel costs tend to be high. This is further emphasised by the fact that the fuel consists of an alloy of zirconium with uranium which is very highly enriched in the fissionable U-235 isotope, the degree of enrichment being so great that the production of plutonium by neutron absorption in the fertile material contained in the fuel is negligible.

Mainly for this reason, the sort of reactor which is in successful use for submarine propulsion in the United States and which is being designed for submarine propulsion in the United Kingdom is uneconomical for application to profit-earning vessels.

It is, however, of interest to look at the design of reactors of this general type. Little has been published about the American reactors, nor is information available for publication about the reactor which is being designed for the British "Dreadnought." However, pressurised water reactors using the same general principles as those used for submarine propulsion, but different in many respects, have been studied for use in land-based power stations. The reactor which the Americans are building at Shippingport, and which is due to go into operation during the first quarter of 1958, is of this type. Extensive studies have been made also of the system in the United Kingdom, although its economics as compared with the Calder Hall type of reactor have appeared to be insufficiently attractive for base-load power stations to make it worth while to proceed with construction under U.K. conditions.

The Pressurised Water Reactor

Fig. 1 shows an outline of the pressurised water reactor developing 400MW of heat evolved in a recent Harwell design study. Certain characteristics of this class of reactor

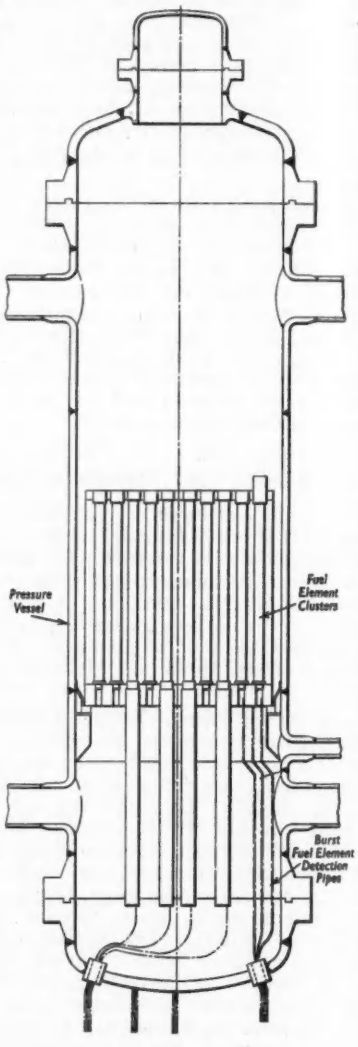

Fig. 1—Pressurised water reactor

can be noted. Most striking is the compactness of the core, stemming from its low fuel to moderator ratio, the good heat transfer properties of water, and the fact that coolant and moderator are the same medium.

Although water is a good low-temperature coolant, it has limitations for high-temperature applications. In order to achieve an

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outlet temperature of 550 deg. Fah., the water in the primary circuit must be pressurised to 1500 lb per square inch, requiring, for a pressure vessel of 10ft internal diameter, a minimum plate thickness of 6in. Owing to the low temperature available, steam superheating is not possible and efficient turbines have to be designed to run on saturated steam.

The fuel elements consist of bundles of rods on a close pitch, and the charge and discharge of these through the thick wall of the pressure vessel is a severe design problem. In this particular design, to give fail-to-safe characteristics, moving fuel bundles occupy a position below the core when the reactor is not operating, while control rods and fuel reloading equipment are located above the core. This layout increases the core length by nearly three times. While acceptable for land-based plants, from a weight per horsepower point of view, this would materially reduce the value of the compact core, and alternative designs would require investigation for marine application.

High-temperature water is highly corrosive. For this reason the uranium would probably have to be in oxide form, and for the same reason plants so far built have been constructed largely of stainless steel or mild steel lined with stainless steel. Even with these disadvantages, however, the pressurised water reactor remains a class of reactor potentially of interest for marine propulsion because of its compact core. Enrichment tends to be high ; for example, a 20,000 s.h.p. unit might require 3 Co material.

The Graphite-Moderated, Gas-Cooled Reactor

With these sort of values for enrichment, there appears little possibility at present, with enriched uranium produced at a cost practicable in Great Britain, that pressurised water reactors could be used for the propulsion of profit-earning vessels.

All the studies related to the generation of electricity from nuclear power plants show, under British conditions, that the more economical type of reactor is the graphite-moderated, gas-cooled reactor of the Calder Hall type. But it has been pointed out that the Calder Hall reactors are massive plants using fuel elements of low rating and, therefore, unsuitable for use in ships. However, the fact that the reactors are most favourable from the point of view of operating cost makes it necessary to examine the possibility of bringing down the weight per horsepower, even though in doing so measures are adopted which would not be economically justified for immediate application in land-based stations. If the weight is to be brought down, it is obviously necessary to increase the specific rating of the fuel elements and so increase the heat output of a given volume of reacting core.

Fuel element ratings have been constantly increasing since reactors were first built in this country. As is well known, the British nuclear power programme is based on reactors using natural uranium fuel. With graphite as a moderator, this necessitates a geometrical form of the uranium with a small surface to volume ratio, typified by the solid rod of about 1in in diameter. Although this form of fuel element promotes good neutron economy, it has far less to commend it from the point of view of transfer of heat out of the uranium into the cooling gas, since the surface swept by the gas is small in relation to the volume of uranium. Temperature gradients in the uranium are steep, as they are proportional to the square of the radius of the rod.

This has stimulated the development of extended surfaces from the fuel elements (or, more exactly, from the cans cladding the uranium) to increase the surface to volume ratio while keeping the uranium itself in simple rod form. The design of effective extended surfaces is involved and has required extensive experimentation to perfect. In order to limit neutron absorption only a few materials, notably aluminium, magnesium, zirconium and beryllium, can be used as cladding material for the uranium. The early reactors used aluminium. An important advance was made when magnesium was introduced for the Calder reactors, as not only does magnesium absorb fewer neutrons than aluminium, permitting freer use of extended surfaces, but also, unlike aluminium, it does not react with uranium. This permitted the fuel element temperature to be raised by about 100 deg. Cent., thereby increasing fuel element rating and making power generation economically feasible.

However, the end of possible development of the single solid-rod, fuel element is approaching. To increase the fuel element rating, the uranium must be spread so as to increase the surface-to-volume ratio of the fuel. This can be done only at the expense of using slightly enriched fuel.

For example, if by an assembly of small rods or flat plates the surface-to-volume ratio of a fuel element is increased a factor of 30, then its specific rating under equivalent conditions will be about five times a single solid rod. It is quite apparent, therefore, that very substantial increases in fuel rating, and so reduction in weight per horsepower, can be achieved in this way.

Before this technique can be exploited in a practical plant, however, due consideration must be given to the effect on the plant of increased rating. Increased rating implies increased neutron flux density, the two quantities being directly proportional. Increased flux density intensifies the irradiation damage in the graphite moderator and the structural materials of the reactor. Corrosion effects, particularly of the moderator by the coolant, are also intensified in the field of the neutron flux. These limits must be firmly established and, where necessary, materials developed to withstand the conditions.

The response of the reactor under fault conditions must be fully analysed, particularly those associated with accidental coolant failure. The rate at which the fuel elements may overheat increases with rating, and the low melting point of magnesium (650 deg. Cent.) leaves little margin for a rise in temperature under fault conditions to cause melting of the cladding material. If this occurred the subsequent exposure of the uranium to the coolant would enable radioactive fission products to escape into the reactor primary circuit. This accident becomes more serious, of course, if the coolant failure has been occasioned by a breach of the gas pressure circuit, when escape of fission products into the reactor compartment could occur.

An effect known as " after heat " peculiar to nuclear reactors still further emphasises the importance of continuity of cooling. This effect occurs after a reactor has been shut down and the nuclear reaction reduced to a sub-critical level. Heat production continues due to the residual gamma radiation arising mainly from the fission products. This heat production is time dependent (see Fig. 2). Guaranteed cooling must remove this residual heat which, although much less than that developed when the reactor is operating at full power, could cause serious overheating of the fuel elements if cooling were inadequate. This requirement exists whether the fuel elements remain in the reactor or are removed from it and must be maintained until the radioactivity has decayed with the passage of time to render the heat production insignificant.

The margin between the operating temperature and the melting point of the cladding

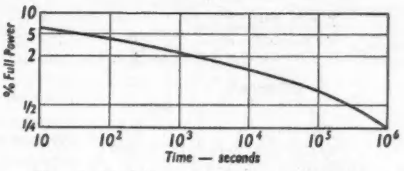


Fig. 2—Variation of afterheat with time

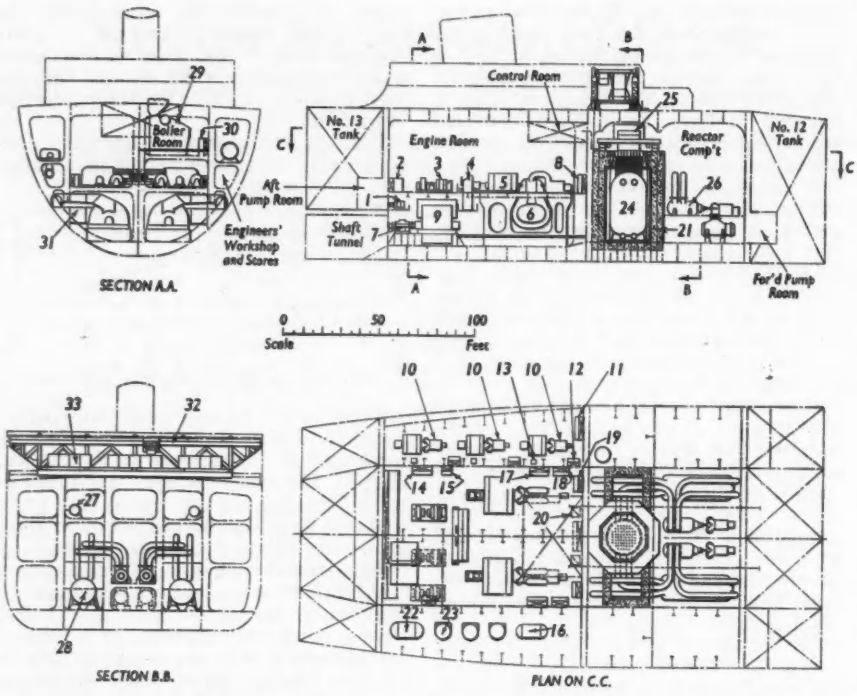
material would be very much increased if zirconium (M.P. 1850 deg. Cent.) were substituted for magnesium (M.P. 630 deg. Cent.). The maximum operating temperature of the fuel elements would have to be increased by about 50 deg. Cent. to compensate for the poorer thermal conductivity of zirconium in relation to magnesium and a slight increase in enrichment would also be involved to offset the former's rather higher affinity for thermal neutrons. It is believed that zirconium could be operated reliably up to about 500 deg. Cent. in carbon dioxide, so that uranium metal clad in zirconium is a real possibility as a fuel element for a highly rated reactor. Similar problems are being faced in the development of our nuclear power stations generating base-load electricity. Here the indications are that the best results will be obtained if fuel elements of uranium oxide clad in beryllium are developed. Beryllium has a low affinity for neutrons and a high melting point (1280 deg. Cent.), while limited but impressive experimental results indicate that the ceramic form of uranium is more irradiation resistant than the metal. The adoption of a high temperature cladding material for the fuel elements would enable the rating of the reactor to be further raised and the size of the heat exchangers and turbine equipment to be reduced. Higher steam pressures and temperatures would also be possible, so raising the overall efficiency of the plant.

Using fuel elements of this sort, it should be possible to achieve ratings which would enable reactors of the graphite moderated, gas cooled type to be installed in large ships. Schemes have been prepared which suggest that they could be effectively used, for example, for the propulsion of tankers down to about 50,000 tons deadweight carrying capacity.

A good deal of experimental and development work is necessary in order to achieve these high performance fuel elements and to investigate fully the problems associated with the materials of a highly rated reactor. It will almost certainly be advisable to build a prototype reactor on land to establish this performance, before incurring the heavy additional expense of putting a reactor of this type into a ship's hull, although it is extremely desirable that a nuclear ship should be in operation as soon as possible.

A Nuclear Powered Super-Tanker

The possibility of propelling super-tankers by a gas cooled, graphite moderated power reactor has been the subject of a recent design investigation. An early scheme was aimed at the development of a 50,000 s.h.p. unit driving a twin-screw 100,000-ton deadweight ship. Later, a more compact 25,000 s.h.p. design was evolved, suitable for a 45,000-ton deadweight vessel, at the lower end of the



(1) Cargo pump motor ; (2) 3·3kV switchboard ; (3) main exciter ; (4) propulsion desk ; (5) 20MW turbo-alternator ; (6) condenser ; (7) thrust block ; (8) main distribution board ; (9) main propulsion motor ; (10) 2MW turbo-alternator ; (11) auxiliary turbine/alternator/motor board ; (12) turbine gauge board ; (13) field pillar ; (14) relay panel ; (15) heater and battery charger supply board ; (16) auxiliary condenser ; (17) main turbine gauge board ; (18) main turbine/alternator/motor board ; (19) heat exchanger and turbo-circulator board ; (20) transformer ; (21) biological shield ; (22) l.p. steam generator ; (23) evaporator ; (24) reactor ; (25) refuelling machine ; (26) turbo-circulator ; (27) heat exchanger steam drum ; (28) heat exchanger ; (29) stand-by boiler ; (30) boiler gauge board ; (31) propulsion motor cooling ; (32) coffin gantry ; (33) coffin

Fig. 3—General arrangement of 50,000 s.h.p. ship installation

super-tanker range. The early scheme is now briefly examined as, although crude, it will serve to bring some of the main problems into focus.

Fig. 3 shows the layout of the 50,000 s.h.p. reactor unit, comprising a reactor and two heat exchangers, each with its steam turbine driven, axial flow compressor to circulate the CO_2 gas between the reactor and the heat exchangers which raise steam for the main drive turbines ; and the general installation in the ship itself, including the turbo-electric drive equipment, selected rather arbitrarily instead of geared turbines, for the final drive.

A few particulars of the nuclear ship and its power plant are given in the table.

Ship :	
Deadweight, tons	101,000
Displacement at load draught, tons	140,600
Block coefficient at load draught	0·77
Length (overall), feet	975
Beam, feet	135
Speed, knots	18·25
Plant :	
Reactor heat output, MW	180
Diameter of reactor pressure vessel, feet	18
CO_2 gas pressure, pounds per square inch abs.	315
Weight of enriched fuel, tonnes	15
Initial enrichment of fuel	1·3 Co
Steam cycle	Single pressure
Steam pressure, pounds per square inch	500
Steam temperature, deg. Fah.	700

The reactor unit takes the place of the complete boiler unit in a conventional power plant, with the other machinery remaining more or less unchanged. The vertical reactor pressure vessel, in which the CO_2 flows downwards, is supported directly from the tank bottom of the ship within the biological shield which is lined internally with a thick mild steel plate in which 80 or 90 per cent of the radiation from the reactor is attenuated. The centre of mass of the graphite moderator is situated some 8ft below the centre of the roll of the ship. Two parallel cooling circuits are provided. Each circuit has its own heat exchanger and gas circulator, which are connected to each other and to the pressure vessel by two 2ft 6in diameter ducts with creased bends.

The heat exchangers are supported, with their axes horizontal, to the side and forward of the reactor at tank top level. The two turbo-driven circulators lie between the inner longitudinal bulkheads in a separate flat some 15ft above tank top level. The reactor is loaded and unloaded with uranium from the top, the deck for this operation being 20ft below upper deck level, the intervening space housing the necessary machinery.

The reactor control room is positioned immediately aft of the reactor above the engine-room, in close proximity to the control equipment. The control rods are mounted on either side of the reactor vessel in compartments shielded from the gas ducts. The gas activity levels in the circulator and heat exchangers necessitate their being contained within lightly shielded compartments. The turbo-circulators and their condensers, the steam drums of the heat exchangers and their associated control equipment which require maintenance are situated outside this shielded area.

The weight per shaft horsepower achieved for the reactor unit and all machinery was about 500 lb per shaft horsepower, of which nearly half is due to radiation shielding required round the reactor unit itself. It is interesting to see that this value represents a very big reduction from the Calder Hall plant and, if present trends are maintained, is a value that will not be reached on land based plants before the mid-1980s.

If a figure of 180 lb per shaft horsepower is assumed for the boiler and propulsion machinery complete for an equivalent conventional plant with turbo-electric drive, it is seen that the nuclear plant is about three times as heavy, of which a large proportion is due to the weight of shielding associated with the nuclear reactor. This is not the complete story, however, because the conventional plant requires 5000 or 6000 tons of bunker fuel oil at the outset of a voyage, whereas the nuclear plant requires only 15 tons of uranium which is sufficient to fuel the ship for about a year. If the weight of bunker fuel is added to the weight of the conventional plant, then the weight per shaft horsepower rises from 180 lb per shaft horsepower to 425 lb per shaft horsepower, roughly equivalent to the alternative nuclear plant.

As the design of this particular nuclear plant materialised, it was found that this rough weight equivalence was also repeated on a volume basis, the length of machinery space to accommodate the reactor unit and main machinery being about 24 per cent of the length of the ship compared with some 17–18 per cent in the case of a conventional tanker.

It can be seen, therefore, that the weight per shaft horsepower of a gas cooled, graphite moderated reactor can be reduced to values becoming acceptable for marine propulsion. As rating increases, however, the core size for a given power output diminishes and neutron leakage starts to become prominent. Furthermore, to achieve high rating, the surface to volume ratio of the fuel has to be increased, tending still further to spoil the neutron economy of the reactor. These adverse effects require the use of enriched fuel, and it can be seen from Table I that 1·3 Co uranium is required for the 50,000 s.h.p. plant.

This is only slight enrichment, however, and the bulk of the uranium still consists of the fertile isotope U-238 which, as described earlier, is transformed in the reactor into plutonium, itself a nuclear fuel. About 0·6 atoms of plutonium are formed for every atom of U-235 destroyed. After the fuel has been discharged from the reactor, therefore, it is made up of depleted uranium, plutonium and fission products, and these are separated in a chemical processing plant. An interesting possibility occurs of reconstituting new fuel with the plutonium, a proportion of the depleted uranium and some fresh make-up. A special case arises when the neutron economy of the reactor is good enough for the make-up fuel in the cycle to be natural uranium. This occurs in the 50,000 s.h.p. unit just described. This reactor, therefore, while requiring enrichment for the first charge of uranium, when operating on a plutonium equilibrium cycle, subsequently would require only a natural uranium feed.

Enriched uranium is manufactured in a diffusion plant, which has a high capital cost and a high running cost, as it is a big consumer of electricity. A large number of ships at sea driven by nuclear reactors requiring enriched uranium would, therefore, need to be backed by considerable diffusion plant capacity. The potential advantage of a reactor which can operate on a plutonium equilibrium cycle with a natural uranium feed is that this capacity is kept small, being related only to the requirements of the first charge of uranium.

The Economics of the Nuclear Powered Super-Tanker

It has been seen that a highly rated graphite moderated, gas cooled reactor, with favourable development, could be designed to drive ships of the super-tanker class. The question next arises as to whether there is any economic advantage in doing so.

The general economic characteristic of nuclear power plants at the present time is that their capital costs tend to be high and their fuel costs low in relation to conventional plants, although as might be expected with plants in the early stages of develop-

ment, there is a marked trend downwards in capital cost. The capital cost estimate made for the 50,000 s.h.p. plant indicated that it was about 50 per cent more than a conventional plant of similar power output.

Fig. 4 shows the specific fuel cost estimated for graphite moderated reactors, of which

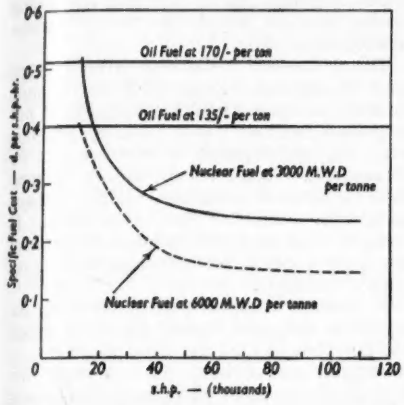

Oil Fuel at 170/- per ton
Oil Fuel at 135/- per ton
Nuclear Fuel at 3000 M.W.D per tonne
Nuclear Fuel at 6000 M.W.D per tonne
Specific Fuel Cost — d. per s.h.p.-hr.
s.h.p. — (thousands)

Fig. 4—Specific fuel cost of the gas cooled, graphite moderated reactor

the 50,000 s.h.p. unit described above is typical. The fuel cost, expressed in pence per shaft horsepower hour, is shown as a function of shaft horsepower developed. This is compared with conventional plant burning oil fuel at 135s. and 170s. per ton. The low cost of nuclear fuel is apparent from these curves. The characteristic rise, as the core sizes become smaller for plants of low shaft horsepower, reflects the effect of increasing neutron leakage from the reacting core. The way in which the curves flatten out at higher powers is due to the same effect, neutron leakage becoming proportionately less as the size of the core increases. It can be seen that below about 25,000 s.h.p. the nuclear fuel costs start to rise steeply. Longer burn-up of the fuel is one way to delay the onset of this effect, as is shown by the dotted 6000 M.W.D. per ton curve in Fig. 4.

The operating costs of nuclear powered super-tankers with a service speed of 17½ knots are shown in Fig. 5, the comparison at 100 per cent being made with conventionally powered vessels fuelled with oil at 135s. per ton. A large number of factors have had to be taken into account in the calculation of these curves, but where assumptions were involved, they were chosen to be conservative.

It can be seen from Fig. 5 how the operating costs fall more steeply with increasing deadweight for the nuclear ship than for the conventional ship. Although the curves do not illustrate this point, the same effect would

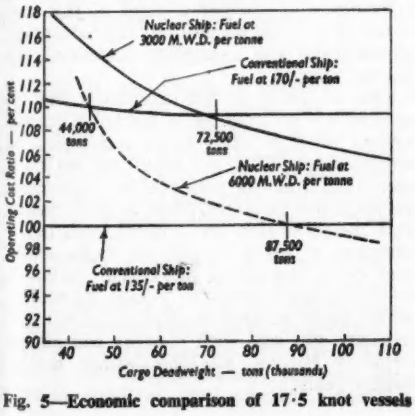

Nuclear Ship: Fuel at 3000 M.W.D. per tonne
Conventional Ship: Fuel at 170/- per ton
44,000 tons
72,500 tons
Nuclear Ship: Fuel at 6000 M.W.D. per tonne
87,500 tons
Conventional Ship: Fuel at 135/- per ton
Operating Cost Ratio — per cent
Cargo Deadweight — tons (thousands)

Fig. 5—Economic comparison of 17·5 knot vessels

arise with increasing service speed. Making actual comparisons with a conventional ship fuelled with oil at 135s. per ton, it can be seen that cost of transport of oil in a 100,000-ton deadweight ship is 6 per cent more than the conventional ship, and about 14 per cent more if the comparison is made for a ship of 45,000 tons deadweight. If oil costs 170s. per ton, then a nuclear ship of about 70,000 tons deadweight breaks even.

For plants in the very early stages of development, these figures cannot be described as disadvantageous to the nuclear ship. As already noted with nuclear plants, there is a strong downward trend in both fuel and capital costs, the dotted line in Fig. 5 showing the advantageous effect which one development alone, that of longer fuel burn-up, can have on the operating cost.

Manoeuvrability of Ship

Some of the practical problems of importance that occur with the marine application of nuclear power should next be reviewed. When the uranium nucleus is fissioned, among the resulting fragments occurs an unstable isotope of iodine (I^{135}) whose decay product, xenon[135] (Xe^{135}) has a profound effect on the control behaviour of the reactor.

The nuclear reaction involved is illustrated in Fig. 6. Xe^{135} has the largest affinity

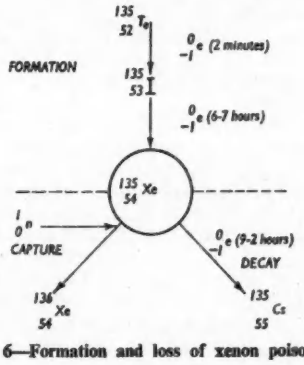


Fig. 6—Formation and loss of xenon poisoning

for neutrons of any isotope. Fortunately it is formed in very small quantities and, being unstable, its life is limited. It is destroyed in one of two ways, either by radioactive decay to Cæsium[135] (Cs^{135})—a stable isotope —or by neutron capture to Xe^{136}, which has a relatively low affinity for thermal neutrons. Equilibrium concentration is reached when the rate of formation of Xe^{135} is equal to the rate of its disappearance, the actual value depending on the neutron flux at which the reactor is operating. In order to maintain the chain reaction when the reactor is operating at full power, sufficient enrichment must be included in the fuel to compensate for the neutron loss by xenon absorption.

In addition, peculiar effects arise when the nuclear power, and hence the neutron flux, is reduced. For example, if the reactor is shut down the neutron flux collapses and the capture mechanism, by which the equilibrium concentration of Xe^{135} is in part controlled, disappears. The subsequent effect on the reactivity for the 50,000 s.h.p. reactor is shown in Fig. 7. The I^{135} concentration decays exponentially from its equilibrium value at a rate determined by its decay constant and the Xe^{135} builds up at the same rate. Since the half-

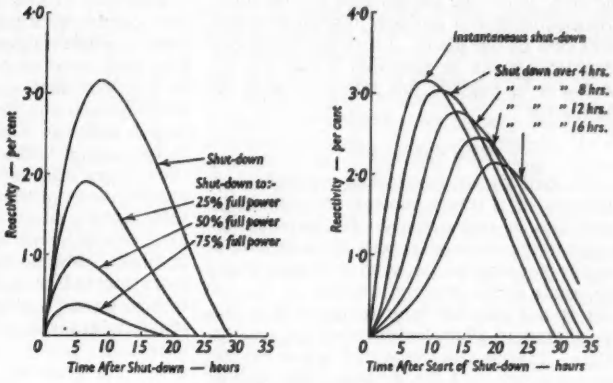


Fig. 7—Xenon poison effect

life of Xe^{135} (9·2 hours) is greater than that of I^{135} (6·7 hours), the Xe^{135} concentration builds up above its normal equilibrium value with a consequent further loss of reactivity. Eventually all the iodine changes into xenon, which in turn changes into cæsium and reactivity is released. A similar effect occurs if, instead of the power being shut down, it is reduced. This can also be seen from the curves in Fig. 7, calculated for power being reduced at different linear rates.

The build-up effect of the Xe poison when the nuclear power is reduced becomes accentuated as the rating of the fuel is increased, and since marine reactors will tend to be highly rated to reduce their weight per horsepower, the effect is serious in this application. It can be overcome, however, in a number of alternative ways.

One obvious way is to add additional enrichment to the fuel, mopping up the excess neutrons under normal running conditions in the control rods and withdrawing the control rods when the excess reactivity is required to override the xenon poison. While this might well be an acceptable solution with low rated reactors requiring little override, with reactors of high rating, careful consideration must be given to whether the xenon override facility is worth the very expensive extra investment in enriched fuel.

If xenon override is not provided, the effect on the manœuvrability of the ship is twofold. First, if the reactor is shut down, a considerable period of time (up to say 24 hours) must elapse before it can be restarted. Secondly, the rate at which reactor power may be reduced is severely limited.

From the point of view of being able to manœuvre the ship at all times, these at first sight seem very awkward characteristics, especially for a ship fitted with a single reactor. The difficulty can be overcome, however, with some additional conventional plant. To cover the case of reactor shut-down, it is necessary to provide another source of standby power. This need be only a small steam or diesel installation, sufficient to give the ship steerage way at sea and provide the heat and power requirement in port in the event of the reactor being shut down for maintenance. Inadvertent shut-downs in practice are very rare so that the call for standby power at sea would be equally infrequent.

Reductions in power can be carried out at the steam end of the plant by allowing the reactor to work at constant power at all times and rejecting the surplus steam to either the

main turbine condensers or to a separate atmospheric dump condenser. Since fuel costs for a nuclear plant are low and ships work at constant power for long periods at a time, the cost of dumping steam in this way has little effect on the actual operating cost of the ship, while the capital cost of the additional equipment is also low in relation to the total cost of the plant. From the foregoing arguments it can be seen that it may not be necessary to provide full xenon override in the reactor.

Reactor Safety

It is well known that locked up in the fuel elements of a power reactor are very large quantities of radioactivity. If this were released to the atmosphere on a large scale in a heavily populated area, such as a busy port, the result would be very serious.

It is not relevant here to develop a full explanation of all the factors related to reactor safety. Marine reactors would follow closely shore practice, and the authors may confine themselves to a few remarks peculiar to the marine application. Broadly speaking, the design principles of safety aim at providing infallible protection ; exploiting the inherent characteristics of a reactor which are stabilising so that overheating of the fuel is avoided if protection does fail ; and, finally, providing several zones of containment between the fission products in the fuel elements and the atmosphere. It is this last concept which might affect the design of a nuclear ship's hull.

For fission products to escape to the atmosphere they must first leave the confines of the uranium, then pass through the cladding material into the coolant, and out through the walls of the coolant circuit. With a ship installation they must then escape from the reactor compartment. If this compartment is made completely leak tight, a further degree of containment would be incorporated. It is suggested that this could be made a requirement of hull design without materially increasing the capital cost of the ship.

Ships are subjected to the external hazards of foundering, collision, grounding and fire. The effect of a nuclear ship sinking has been the subject of considerable study. The general conclusions are that no hazard would arise in oceanic waters and in coastal waters damage to fisheries or contamination of the sea shore might occur if the corrosion rate of the fuel elements exceeded about 0·1 per cent per day. This is a high corrosion rate and it may well be possible to specify fuel of which the corrosion rate in sea water is much less.

Salvage of a sunken nuclear ship should be quite feasible. Because of the very substantial shielding which would be provided by the sea water, there would be little hazard to divers operating in the vicinity of the reactor. Continuous radiological control of the operations of the divers working on the reactor would be necessary, but as long as they did not enter inside there would appear to be no special difficulties in salvaging a nuclear powered ship.

By proper design of the ship's hull, the reactor (which is located anyway behind strong, thick shielding) can be provided with additional protection against the effects of grounding and collision. It can be seen by reference to Fig. 5 in the design of the super-tanker that coffer dams have been provided fore and aft of the reactor compartment ; the reactor is located above the double bottom and has watertight wing bulkhead compartments on either side. Of the possible cause of fission product dispersal to the atmosphere, perhaps the risk of fire is the greatest. The risk can be minimised by measures which prevent a fire arising outside the reactor compartment from spreading to the reactor itself, such as flooding the reactor compartment with CO_2 or water. Fuel in the form of uranium oxide, which will not burn in air (a likely form for marine reactors) would constitute a valuable ultimate safeguard.

Technical problems, however, are not the only ones in relation to reactor safety which need careful thought. For instance, in locating land based reactors the present practice is that they shall not be located in densely built-up areas and there seems to be no reason why a different standard should be adopted in connection with ship based reactors. But such ships will have to enter ports which are frequently surrounded by areas which are fully built-up and it is, therefore, necessary to give careful consideration to the problems involved. Marine reactors will also operate from time to time in the territorial waters of a foreign power, and so will be affected by their regulations, and the problem becomes international.

Shipboard Conditions Affecting Reactor Design

The reactor and machinery installation in a ship are, of course, subjected to acceleration forces and fluctuating deflections imposed by cargo loading and heavy weather, not experienced by shore installations. In the super-tanker study, the resulting accelerating forces, assuming harmonic motion, were calculated for roll, pitch, heaving and vibration, as defined by conservative values of amplitude and period. In addition it was assumed that these motions occur simultaneously. No difficulties were found in designing to withstand the resulting forces. There is an obvious advantage in locating the centre of gravity of the reactor and its heavy shielding as near as possible to the centre of roll of the ship to minimise the rolling acceleration forces. The greatest deflection of the ship's structure is that due to longitudinal bending. Again, where this was evaluated, there appeared to be no insuperable difficulties from the design point of view

It is considered desirable to design the reactor unit to remain structurally stable in the event of the ship capsizing, and the control rods so that they will function in any normal or abnormal position of the ship. In general, although the heavy concentrated loads of the reactor and its shielding require special design measures for its support within a ship's hull, provided the design of the plant and the hull are properly integrated, it is not thought that any overwhelming engineering difficulties would be encountered.

For charging and discharging a shore based reactor with its fuel, it has become the practice to design so that this may be carried out on a continuous basis while the reactor remains operating at full power. This may become acceptable marine practice. Alternatively, since faulty fuel elements are rare, on condition that adequate means are provided for dealing with them if they arise at sea, the normal discharging of the uranium could be carried out in port. With a small reactor, the complete core could be periodically replaced. With a larger reactor, turn round time of the ship could be reduced and a better fuel economy realised if a proportion of the core was discharged periodically, so approximating to the continuous charge and discharge scheme.

General Conclusions

It has already been stated that it appears possible that reactors of the graphite moderated, gas cooled type can be used for the economic propulsion of ships requiring about 25,000 s.h.p. or above. Their use at smaller powers does not at present appear promising. Although there is a tendency for ship sizes to increase, by far the greatest part of the world's shipping is to-day in ships of under 20,000 tons, and it appears probable that these smaller ships will continue to have great importance. It is, therefore, necessary to consider what chance there is of developing nuclear reactors, which can be used economically in such ships.

The pressurised water reactor of the type used for submarine propulsion can certainly be made sufficiently light for this purpose, but because it uses nearly pure fissile material it is extremely questionable whether it can be economical. Such a reactor can be designed to use uranium of moderate enrichment where some regeneration of fuel takes place. It remains to be seen to what lower power level the reactor could be built and have competitive fuel costs.

A similarly compact reactor could be designed by using an organic liquid, of which the polyphenyls look the most promising, as moderator and coolant. As with water, the light hydrogen atom offers good moderating properties, while the low vapour pressure of the organic liquid permits low pressures of the order of 150-200 lb per square inch in the primary circuit, materially easing the pressure vessel problems associated with water reactors which require pressures of ten times these values. Up to the present, however, although a considerable amount of development work has been done, no organic liquid has yet been found which is stable under irradiation. They all break down with gum formation, which would be fatal to the successful operation of the reactor.

It is of course possible to achieve very high ratings by using a liquid metal as a coolant in a reactor. Sodium appears to have the best properties but these leave much to be desired. It reacts violently with water, ignites in air at temperatures above about 150 deg. Cent. and becomes highly radioactive on passing through the reactor, requiring the whole of the primary circuit to be heavily shielded. The Americans designed a second type of reactor for submarine propulsion using this system, but have abandoned it after trials in favour of the pressurised water reactor which has given them such satisfactory results.

A reactor using heavy water as a moderator and gas as a coolant has been considered. Heavy water is a much better moderator than graphite, but used in this form of reactor, where the coolant must be physically separated from it, the means of separation introduces absorber into the core detracting from its good neutron economy. It seems, however, that a system of lower enrichment than a graphite moderated reactor may be possible, although any saving in fuel cost must offset the cost of the heavy water, which for a reactor of say 20,000 s.h.p. would cost about £250,000. It is doubtful whether a plant of this sort would give much weight and size advantage as compared with a graphite moderated, gas cooled reactor.

One is forced to the conclusion that at present it is not possible to foresee a reactor system which is likely to be economical in smaller ships. This, of course, does not mean that such reactors will not be discovered. Development is taking place at a surprising rate and all of this development tends in the direction of lower weight per horsepower, and lower capital and fuel costs. Although to-day we are not able to foresee the reactor which could be used in ships of 20,000 tons capacity and less, such reactors will almost certainly become available within ten to twenty years.

Experiences with the Fell Locomotive

A paper on the Fell diesel mechanical locomotive which was presented before the American Society of Automotive Engineers on November 5 last included some particularly interesting notes on experiences with the locomotive on trials and in service. Although it was generally known that difficulties had been encountered with the locomotive when it started running, little information on the true causes of the troubles was generally available. These troubles and the modifications subsequently made to eliminate them are described in some detail in the sections of the paper we reproduce here. From these abstracts it will be seen how the difficulties which might normally be expected with a completely new design can be accentuated by sheer misfortune and oversights which could not have been foreseen. The paper, which was prepared by Lieut.-Col. L. F. R. Fell and presented by Mr. G. M. Barrett, opened with general notes on the design of the locomotive—which was described in detail in our issue of June 1, 1951. It concluded with the results of dynamometer car tests and particulars of a projected design incorporating improvements in the light of experiences with the prototype locomotive. As a matter of interest it will be recalled that a preliminary report on the tests of the locomotive with dynamometer equipment was reproduced in THE ENGINEER *of January 27, 1956.*

VERY shortly after the engines had been started for the first time in December, 1950, the prototype locomotive No. 10,100 was driven out of the erecting shop in Derby under its own power and trials began on a branch line. Development work proceeded as detailed below, before and after the locomotive entered revenue earning service in the beginning of 1952.

All controls excepting the driver's regulator are actuated by vacuum diaphragms so as to make use of the vacuum supply already created for the continuous brake system. The pipework involved in the duplicated controls and exhauster needed several modifications, which were carried out during the course of 1951. Additional reservoir capacity was required for satisfactory operation of the controls. The vacuum services to both the gearbox release clutch—originally vacuum operated—and the reversing system received intensive study to speed up their operation under all conditions of depression in the brake pipe. The fully pneumatic controls have never been the cause of any anxiety in service and the locomotive is very popular with drivers.

The water coolant system, which is common to all six engines and involves the use of end radiators, was originally pressurised, but steam formation in the water pumps and radiators and consequent breakdown of circulation was experienced. Many tests and modifications were carried out between April and October, 1951, but the solution remained elusive until the inclusion of cyclone steam separators in the outlets from each engine: the steam and water were vented back to the header tanks, with a make up pipe returning to the eye of each pump. This system has been satisfactory at atmospheric pressure under all conditions of load and weather.

Gearbox

During the early trials in January, 1951, after a total of 80 miles, the No. 1 end reversing dog clutch tightened on its shaft; the clearance on the bottom fitting splines was only 0·004in and both clutches and shafts were returned to the makers for the clearance to be increased to 0·010 in, which cured the trouble.

Evidence in the gearbox oil of lead bronze, used in the bearings for the planet gears, made it necessary to strip the differentials. The planet wheel bearings are steel-backed copper-lead bushes pressed into the planet gears of the differentials and running on stationary hardened steel spindles. In the secondary, one planet gear had seized on its spindle, which had rotated in the casing, and a machining error had allowed one planet gear to "end mill" against one of the sun wheels. This gear had to be replaced. The planet gear bearings of all three differentials had insufficient clearance both diametrically and axially and sharp edges had not been removed from oil grooves.

After 20 miles had been run in May, 1951, reversing was found to be difficult, and tightness in the secondary differential was evident. This was again found to be due to a seized bush. The spindle was insufficiently hardened, but this was only a contributory cause. Many additional drillings were made to increase the oil feed to these bearings and the clearances were again increased. These modifications allowed satisfactory operation of the gearbox until the accident in 1952, referred to later on, when examination revealed that further detailed changes were desirable.

The bearings were originally half bushes, with a flange faced with the same bearing material which made contact with the inside of the mild steel differential casing. There is no positive end loading but a tendency for the bushes to wind out of the gear was apparent which resulted in the flanges firing up against the differential casing and transmitting excessive heat to the bearings proper. The new bushes were flangeless and were prevented from moving axially in the planet gears by inspringing circlips trapped in the grooves ground in the bores of the planet gears and corresponding grooves on the outside surfaces of the bushes. A good bearing surface for the hard end faces of the gears was provided by the insertion of flanged cast iron bushes pegged to the inside faces of the differential casing. The arrangement was seen to be eminently satisfactory when examined in October, 1955, although two bushes had rotated inside their planet gears. The two bushes were replaced with a higher interference fit.

In September, 1951, one of the Timken roller axle box bearings seized solid when the locomotive and twelve coaches were blocking the "down" express line and both slow lines near Kettering. The axle boxes of all driving axles contained virtually no lubricant owing to a misunderstanding. In an effort to move the locomotive so as to clear the main line, our engineers engaged a fluid coupling with the engine running at maximum speed, by overriding the drivers control. Whilst the torque developed was insufficient to move the locomotive against the seized axle, it was sufficient to displace the side rod cranks on all the axles by several degrees. This gross overloading of the gearbox was, to a large extent, to blame for a subsequent failure.

In July, 1952, after about 35,000 miles running the toothed ring which provides the output from the secondary differential casing came adrift due to failure of the $\frac{3}{4}$in securing setscrews, the head of one dropping between the teeth of the reversing wheels at about 50 m.p.h. Nearly all rotating parts below the secondary differential suffered damage. In a disaster of this magnitude it was essential to inspect every component, including those not subjected to primary damage, for cracks or misalignment. Fortunately all castings were undamaged. All shafts were re-used, although several required plating to bring up the interference fit for the inner races of bearings which had rotated and to reclaim splines either worn, or torn in the operations of fitting and removing the gears. Two bearings were broken and had had debris rolled into the tracks; all ball and roller bearings, approximately fifty, were reconditioned or renewed. Poor deliveries of replacement material resulted in the locomotive standing idle for twenty months after this accident.

The take-off gearing which had been torn from the casing of the secondary differential was pronounced fit for further service. It was refitted with larger dowels and setscrews. In order to prevent the recurrence of a metallic body falling on to the two reversing gears and being rolled through the mesh, the two gears were interchanged so that in the upward sense rotation is now outwards. The train of five gears connecting the final drive gears was also protected from above by covering with a shield.

Torque Release Clutch

Three faults were apparent in the original "Ferodo" lined multiplate clutch: it had insufficient torque capacity and no ability to dissipate heat, and was built adjacent to the wrong engine. Alterations in the gear ratios between the output from the primary differentials and the input to the secondary to increase the speed range had been made and the gearing of "A" and "B" engines was now lower than that of "C" and "D" by the ratio of 1 : 1·19; since "A" engine was commonly used for starting, the torque at the clutch was unnecessarily increased by this factor. A few revolutions of slipping were sufficient to buckle the thin steel plates in the clutch which would not thereafter free themselves when required, and reversing became a hazardous procedure. Flattening and straightening clutch plates became a Sunday routine to the detriment of other maintenance.

A traction clutch, operated by oil pressure, was purchased from Modern Wheel Drive, Ltd. The size purchased fitted into the space occupied by the former clutch and has about 60 per cent reserve in torque capacity. Oil pressure was obtained from the gearbox circuit. The two oil pumps were each fitted with a spring loaded valve to give an oil supply to the clutch at 65 lb per square inch. The quantity of oil required is small except when it is moving the clutch plates, and the bulk of the oil is passed on to lubricate the gearbox at 10 lb per square inch. The operation of the clutch control valve was effected conveniently by a lever arm attached to the shaft connecting the drivers' regulators, which enabled the valve to be sited adjacent to the clutch. The lower ratio of "A" and "B" was changed over to "C" and "D" engines by interchanging the take-off gears attached to the primary differentials, and also the gears splined to the half shafts of the second-

ary differential. Thus " C " engine could be made the starting engine without loss of tractive effort, in which case the clutch carries no load. The pipe work to the valves of the drivers scoop controls which engaged the drive of each engine was interchanged to achieve the order " C," " D," " A," " B," so that operation was normally left to right as before.

Apart from some initial sticking due to the clutch faces not having been mated—since in this application the clutch is never engaged with the faces rotating—the operation of the clutch has been faultless and no maintenance has been required.

It was decided early in the trials that an increase in starting effort was desirable. This was accomplished with the least sacrifice in maximum speed by altering the ratio of the bevel gears at the input to the gearbox of one engine only, which brought the theoretical starting tractive effort up to approximately 33,500 lb and reduced the maximum governed speed to 74 m.p.h. The torque now available is just less than that required to slip the wheels on a dry track freely sprinkled with sand—the sand having been applied by hand.

Main Engines

The ease of changing one of several relatively small engines as opposed to repairing a single large one *in situ* was expected to be a feature of the locomotive. Unfortunately the position of the cab bulkheads prevents a direct vertical lift and thus seriously interferes with engine changing. Ease of engine removal would have been advantageous on only two occasions in the life of the locomotive up to now, for otherwise repairs to the main engines have been of a minor nature. Generally all components were seen to be in excellent condition after stripping for examination of 1953 and October, 1955. Although in the past the unusual torque curve on which the engines are operated has brought forth some pessimistic comment, Davey Paxman and Co., Ltd., are now confident that at least 4000 hours will be realised between inspections.

On March 21, 1954, " D " engine ran up to over 1900 r.p.m. for several seconds when the drive was disengaged to coast down hill. Examination of the fuel injection pumps revealed that the dowel-ended setscrew which prevents rotation of the rack bar had broken in one pump and the broken piece had spragged the rack in the part open position. Four pistons were withdrawn for inspection but were in good condition and the engine had suffered no damage, although the valve springs were replaced since they had reached " surging " speed and shed some of their cadmium plating. As a safety precaution the bolts through the big end bearing were replaced.

This misfortune provided additional stimulus to Messrs. Davey Paxman in the production of a novel overspeed trip built into the multi-element fuel injection pumps. A centrifugal flyweight mounted on the free end of one fuel pump camshaft was arranged to rotate a shaft inside a pump block which pressed a set of plungers against the fuel pump tappets. Each plunger slides beneath the edge of the corresponding tappet as the latter reaches the top of its stroke and prevents further movement of the reciprocating element. This equipment was developed in conjunction with and manufactured by C.A.V. Ltd. Very little development was required on those components contained within the fuel pump, but the original flyweights were very unstable owing to cyclic and torsional oscillations of large amplitude, since there are several components between flyweight and crankshaft flywheel. After several experiments Davey Paxman were able to produce a centrifugal unit which tripped consistently on the test bed, but it was found to be unstable on the locomotive even after a spring hub had been incorporated in the drive. A stroboscopic lamp was borrowed to examine the behaviour of the flyweights on the locomotive, and it was then apparent that a phenomenon, previously experienced at idling speeds and described as " shuttling " of the rack bar in the fuel pump, was again encountered at speeds approaching normal governed maximum. This movement was initiated by cyclic oscillations (the governor drive being remote from the engine flywheel) and amplified by the servo mechanism within the governor. As a temporary measure an inertia damper of 10 lb mass was attached to the rack of each pair of fuel pumps. This temporary expedient proved entirely satisfactory in the first week of service—November, 1954—and remained attached throughout 1955. Messrs. Davey Paxman have experimented with various spring drives to the governor without success. These experiments were greatly retarded owing to inability to reproduce on the test bed the savage " shuttling " experienced on the locomotive. The condition was eventually reproduced after patient exchanges of the six governors available and a cure was effected on the test bed with a modified servo piston in the governor.

A harsh metallic noise emanating from the Bibby couplings when " C " and " A " engines were idling caused much embarrassment at stations. This noise could be associated with rack bar shuttling. The couplings were greased daily with a bituminous compound which alleviated the noise to some extent. The modified servo piston now prevents undesirable liveliness at all speeds.

Fluid Couplings

The damage to " D " engine fluid coupling caused by the engine overspeeding in March, 1954, was fortunately confined to the outer reservoir casing which had bowed and started to crack across a welded seam, and slight distortion of the inner casing in the vicinity of the quick emptying valves. The new casings were rolled from heavier gauge steel to increase the safe maximum speed.

On July 22, 1955, the scoop tube of " A " fluid coupling seized internally. When examined at the works of Fluidrive Ltd., the tube was seen to have cracked and folded back. In traffic the drivers are encouraged to coast down hill, following which the fluid couplings are filled at high rotational speed when the bending moment on the scoop tube will be considerable. Although this condition of operation had been recognised and a strengthening patch had been brazed to the tube during manufacture, the crack had occurred across the patch. Messrs. Fluidrive agreed to replace the scoop tubes of all four couplings with stiffer solid drawn tubes and in addition to take the opportunity of rolling new casings for " A," " B " and " C " couplings to give the same safety factor as that of " D " coupling.

Boost Air System

The test running in March, 1954, revealed the lack of provision for cleaning the intercoolers, and detachable panels were cut in the trunkings so that these could be swilled with solvent. The primary object of cutting the panel at the No. 1 end was to remove a large sheet of rubber which had inadvertently been acquired during the overhaul. The measurements of pressure drop necessary to establish this intrusion also revealed a restriction in the fabricated junction below each intercooler. Opening up the internal passages reclaimed a 50 per cent increase in area.

The noise baffles outside the air filters collected quantities of soot blasted from roofs of tunnels by the exhaust outlets, which emerge each side of the centre line. A shield was fitted to protect the intake slot from above, which reduced the cleaning of filters from weekly to three-monthly.

Final Drive Components

Failure of bearings in the rods coupling the driving wheels caused by far the greatest loss of running time during the first six months of traffic. Owing to the small wheels, 4ft 3in diameter, centrifugal loads and rubbing speeds were greater than any previously experienced on English railways. Although several detailed improvements were made the reliability was not proved at the close of the first six months. British Railways, therefore, reached agreement with Fell Developments, Ltd., to reduce the rotating weight on the driving cranks by removing the middle rods between the axles which are already coupled by gears. A new set of rods was made with bearings incorporating those features previously found to be an improvement, and also with improved oil reservoirs to achieve better control of the lubrication. These rods were satisfactory for 32,000 miles, when a felt pad was lost out of a bearing which resulted in damage and some of the bushes were replaced.

Carriage Warming Apparatus

Unless adequate provision is made for steam heating the train, any locomotive is certain to be " failed " in winter and designers of diesel locomotives must, therefore, achieve a reliability for this equipment equal to that of the power unit and transmission.

In the original design for 10,100, two boilers, each capable of about 700 lb of steam per hour, were envisaged. Only one boiler was, however installed, and this was uprated to nearly 1000 lb per hour ; in traffic the further increase available, by utilising the engines exhaust system to provide hot feed, was expected to be sufficient. The locomotive was often coupled to cold coaches in February, 1952, and about fifty minutes elapsed before steam reached the eleventh coach.

Two methods of producing more steam were explored, further use of engine exhaust heat for feed water and superheating, and also the fitting of the second boiler. As originally piped the feed heaters did not contribute as much as had been hoped to the overall output of the boiler, since under certain conditions these generated steam when the boiler required water ; the low water safety switch then came into operation and caused a total shut down. The modifications to prevent this would not have been difficult, but British Railways eventually decided the feed heaters could be a danger to the public and they were disconnected. The fitting of the second boiler had to be rejected on the grounds of too small a margin of surplus electrical capacity as the locomotive electric supply is dependent on 24V generators mounted on the auxiliary engines.

Measurements taken during the dynamometer car tests showed the maximum output of the boiler to have fallen to approximately 550 lb of steam per hour, even though the fuel pressure relief valve at the burner was screwed down to obtain maximum fuel input for these tests. Full speed at the air blower was no longer being obtained due to deterioration of the motor. This has now been rectified.

Criticism of Locomotive 10,100

Having now described locomotive 10,100 and considered the results obtained in service and on dynamometer car trials, before passing to the question of our plans for the future, it is useful to include some remarks on what would appear to be the main defects which have come to light in the design of locomotive 10,100.

Probably the most serious criticism would be levelled against the general congestion and poor accessibility of some of the components. In the main this is due to the basic layout in which the main engines are placed at the extreme ends of the locomotive driving through shafting under the cab floor into the machinery compartment between the bulkheads behind the cabs. Had all the machinery been contained in one compartment between the driver's cabs side type radiators could have been used with a great simplification of the water system, also the engine exhaust and air systems could have been arranged much more conveniently. The present arrangement was chosen so as to avoid siting the cabs at the extreme ends of the locomotive which at the time was considered unacceptable for psychological reasons.

The selection of a rigid frame design of locomotive limited the permissible length over buffers to 50ft. This short length renders necessary the side-by-side arrangement of the main engines. In the next section of the paper it is shown how bogie locomotives can be arranged so as to avoid the side-by-side arrangement, thus providing greatly improved accessibility.

Generally speaking it is now our view that the assembly of four main engines and two auxiliary engines on one underframe is too complicated and as we show later would not be repeated. It is preferable to use on one underframe two main engines and one auxiliary engine, all of larger power, an arrangement which is made possible by a modified transmission system.

Throughout the design of 10,100 the limitations of the British loading gauge presented a somewhat serious handicap and a very much better and more powerful locomotive unit could have been achieved in the greater space provided by the American loading gauge.

Conclusion

The Fell system only uses components which are already well known and thoroughly established by long usage in other capacities. No highly specialised and, in consequence costly, parts are needed. If further proof was required of the high efficiency of the system it is to be found in the fact that no cooling system has to be used at any point in the transmission. In practice its operation by drivers has been found to be foolproof.

The ratio of the power transmitted to the rail to total weight of locomotive is, we believe, unexcelled without resorting to special lightweight construction, which would be unacceptable to the majority of locomotive engineers, or high rating of the engines ; all engines operate well below the makers' maximum guaranteed loadings.

Whilst the prototype locomotive, as has been indicated, is far from representing the full capabilities of the Fell system, it has succeeded in demonstrating for the first time that it is possible to produce and operate in regular passenger service a diesel locomotive unit of top power with mechanical transmission. Great credit is due to British Railways for their part in this achievement.

Water-Wheels, Horses and Steam Engines

By A. K. BRUCE, M.I.Mech.E., Mem.A.S.M.E.

NOTWITHSTANDING the success which attended the introduction of the rotative steam engine, both the horse-mill, the water-wheel and the combined steam engine and water-wheel methods of obtaining rotary motion were in use in Great Britain until well on in the nineteenth century. Stuart mentions the case of a Nottinghamshire worsted spinning mill where a Savery engine was used to supply water to the water-wheel driving the mill machinery. This installation was changed as late as 1793 not by installing a Watt rotative steam engine, but by substituting, for the Savery engine, a Newcomen-type atmospheric engine made by Thompson of Ashover. We also read of a case in 1797 where the layout for a new brewery included, beside the engine equipment, a horse-mill " to work machinery when the steam engine is under repair." Even to-day the horse-mill can be found in use, here and there, for sundry agricultural and other purposes.

According to Stuart, the first instance of the employment of a Newcomen engine for the purpose of pumping up water to supply a water-wheel was in 1752, by Champion, near Bristol. In 1783 Arkwright set up a cotton mill at Shude Hill, Manchester, the machinery being driven by a water-wheel supplied with water by an atmospheric steam engine which pumped the water from the tail race back to the head race. Matthew Boulton himself installed a Watt pumping engine (the famous " Old Bess ") for pumping the tail race water back to the head race of a water-wheel at the Soho Manufactory. This engine (installed during 1777) is said to have been in use at Soho until the Manufactory ceased operations in 1848. The cylinder size was 33in diameter by 7ft stroke, pump barrel diameter 24in. Parts of " Old Bess" are preserved at the Science Museum, South Kensington, these parts including the steam cylinder, piston and piston rod, and the trussed timber beam with chains and plummer blocks. Most memorable, however, in its influence on the development of the Watt steam engine was the water-wheel at Bersham Iron Works, near Wrexham. When, during 1761 or 1762, John Wilkinson the famous iron master took over from his father, Isaac Wilkinson, the running of the works at Bersham, the power for blower operation and other purposes was provided by water-wheel. It may hardly be doubted that at the outset John Wilkinson's interest in the steam engine was powerfully stimulated by the difficulty in obtaining from the water of the Clywedog —the stream supplying the Bersham wheel—sufficient energy for driving the blower cylinders, &c. A dominating advantage of the rotative steam engine was, of course, the scope it afforded for locating the power unit where it could prove most convenient to the power user. In cases where water mills —or combined water and steam mills—were employed for producing rotary motion, the work had to be carried to the power.

It was not until 1782-1783 that Boulton and Watt delivered their first rotative engine, though at an earlier date Wasbrough and Pickard had been granted patents (Nos. 1213/1779 and 1263/1780) covering the application of mechanism " which when applied to a steam engine or any other reciprocal movement, produces a circular or rotative motion without the medium of a water-wheel" (Wasbrough). It is on record that when, during 1781, the Commissioners of the Navy were offered a rotative steam engine as proposed by Wasbrough for driving a flour-mill at Deptford Victualling Yard, they deemed it desirable to consult Smeaton. This eminent man submitted a report which Stuart, giving the text quoted below, described as " in itself a curiosity ":

" I apprehend (wrote Smeaton) that no motion communicated from the reciprocating lever of a fire-engine can ever produce a perfect circular motion, like the regular efflux of water in turning a water-wheel. All the fire-engines that I have seen are liable to sudden stoppages, and may, in the course of a single stroke, pass from almost the full power and motion, to a total cessation ; for whenever, by inattention of the engine-keeper, the elasticity of the steam becomes too low, the engine will be incapable of continuing its motion. The fire-engine seems peculiarly adapted for raising water, and then a stoppage for a few strokes is only a loss of so much time ; but such stoppages in the motion of millstones for grinding corn would greatly confuse the regular operation of the mill, as it would stop with the stones full charged with corn, and before the motion could be renewed the stones must be raised up from their bearings. By the intervention of a water-wheel, these uncertainties and difficulties are avoided, for the work is, in fact, a water mill, and if there is a sufficiency of water in the reservoir to work the mill one minute, without sensible abatement, it will seldom happen but that the engine may be set a-going again in less than half-a-minute after it stops by any common accident, so that the mill will continue regularly at work." It is an indication of the prescience and courage of Boulton that at the time Smeaton furnished his report to the Navy Board, Boulton should have been advising potential engine users that :

" We are now applying our engines to all kinds of mills, such as corn mills, rolling iron and copper, winding coals out of the pit, and every other purpose to which the wind or water-mill is applicable. In such application . . . these mills may be made very much more powerful than any water-mills in England."

It will be noted that Smeaton was a strong advocate of the combination of a reciprocating steam engine and a water-wheel as a means of obtaining rotary motion, the engine being used for pumping water to the upstream side of the water-wheel. He had devoted much study to the production of power from water-wheels and the *Philosophical Transactions* of the Royal Society contain a paper by him describing " An Experimental Enquiry concerning the Natural Powers of Wind and Water to Turn Mills." For this paper—contributed in 1759 and subsequently translated into French—Smeaton was awarded a gold medal.

" Old Bess " had been in service for about ten years when, during 1786, the celebrated Thomas Jefferson, author of the Declaration of Independence, and twice President of the United States, arrived in England. He had already examined—at Nîmes—a steam pumping engine and water-wheel combination (the

engine being af atmospheric type) and while in London he visited the Albion Mill, Southwark, then recently inaugurated and widely publicised by reason of the scale on which rotative steam engines had been applied here for driving a flour mill. Jefferson's visit must have taken place early in March 1786 and in a letter to Charles Thomson, Secretary of the Continental Congress, he writes as follows :

" I remember you asked me in a former letter whether the steam mill in London was turned by the steam immediately or by the intermediate agency of the water raised by the steam. When I was in London Boulton made a secret of his mill, therefore I was permitted to see it only superficially. I saw no water-wheels and therefore supposed none."

A further letter from Jefferson to Thomson contains, *inter alia*, the following example of the accuracy and rapidity of comprehension which characterised that great man :

" I could write you volumes on the improvements which I find made and making here (he is writing from London) in the arts. One deserves particular notice, because it is simple, great, and likely to have extensive consequences. It is the application of steam as an agent for working grist mills. I have visited one lately made here. It was at that time turning eight pairs of stones. It consumes a hundred bushels of coal a day. It is proposed to put up thirty pair of stones. I do not know whether the quantity of fuel is to be increased. I hear you are applying this same agent in America to navigate boats, and I have little doubt but that it will be applied generally to machines so as to supersede the use of water ponds and of course to lay open all the streams for navigation. We know that steam is one of the most powerful engines we can employ, and in America fuel is abundant."

The above passage was written by Jefferson about two months after the starting-up of the first of the Albion Mill engines and, since Dickinson states that this engine was not put on load for some weeks later, Jefferson must have seen the mill within a comparatively few days of the commencement of its commercial operation. That Jefferson saw the installation " superficially," may have been due to the fact that adjustments had not, in March 1786, been completed, the layout of the mill—which was planned by Rennie—having involved an altogether exceptional amount of millwright work apart from the circumstance that the parallel motion on the engines was new. Watt had only recently (October 27, 1785) satisfied himself that the parallel motion on the much smaller engine at Whitbread's Brewery was operating smoothly. Writing of the equipment at Albion Mill, Muirhead states that Peter Ewart, Rennie's apprentice, " was sent from Scotland expressly to assist in the erection of those mills and was employed for four years upon them as a millwright ; when his great mechanical talents and industry sufficiently recommended him to his future employers, patrons, and friends, Messrs. Boulton and Watt."

Jefferson was certainly correct in supposing that water-wheels were not installed, though he may not have realised that he was looking at one of the very early Watt engines of rotative type. At the time Jefferson saw it, this particular engine was, however, an example of the latest steam engine practice, being double-acting (with Watt's parallel motion) and of the impressive cylinder size of 34in by 96in. In a later letter to Thomson (the text of which is printed in a collection selected by Dr. S. K. Padover and published recently in an interesting volume entitled *A Jefferson Profile*), Jefferson, writing from Paris on December 17, 1786, confirms that " steam is the immediate mover " of the machinery. He goes on to mention that he " has had a conversation on the subject of the steam mills with the famous Boulton, to whom those of London belong, and who is here at this time. He compares the effect of steam with that of horses, in the following manner : six horses, aided with the most advantageous combination of the mechanical powers hitherto tried, will grind six bushels of flour in an hour ; at the end of which time they are all in a foam, and must rest. They can work thus, six hours in the twenty-four, grinding thirty-six bushels of flour, which is six to each horse, for the twenty-four hours. His steam mill in London consumes one hundred and twenty bushels of coal in twenty-four hours, turns ten pair of stones, which grind eight bushels of flour an hour each, which is nineteen hundred and twenty bushels in the twenty-four hours. This makes a peck and a half of coal perform exactly as much as a horse, in one day, can perform."

In the letter quoted above there is no mention of Watt, though the meeting with Boulton must have taken place on the occasion when, during 1786, Boulton accompanied Watt on a visit to France where they examined the famous " Machine de Marly," a complicated aggregate of water-wheels and pumps which had been installed in or about 1682 for pumping water at Versailles. Writing of this noisy monstrosity Belidor remarks that " *il ne paroît pas que l'on ait jamais exécuté de machine qui ait fait autant de bruit dans le monde que celle de Marly.*" Desaguliers, writing in 1744, relates how the machine at Marly is said to have cost " above eighty millions of French livres, which is above four millions of pounds sterling. Some of the largest of our fire-engines at present in use in England, will raise as much water to the same height, and not cost above ten thousand pounds." Both Benjamin Franklin and Thomas Jefferson had seen the " Machine de Marly " and they would share the low opinion expressed by James Watt, who regarded it as a mechanical curiosity rather than a world wonder. Certainly the comparison with the double-acting rotative engine driving the Albion Mill must have deeply impressed Jefferson, who was among the first to realise that industry in Great Britain was no longer at the mercy of water-wheels, horses and windmills, but that the development of the rotative steam engine with separate condenser had placed at the disposal of the British manaufacturer power resources which were at once unlimited, dependable and cheap. No doubt Jefferson would hear of the strenuous opposition to the application (1784) by the promoters of the Albion Mill Company for a charter of incorporation. We read that " It was so strongly opposed by the millers and mealmen, on the ground that the application of steam power to flour-grinding would throw wind and water-mills out of work, take away employment from the labouring classes, and reduce the price of bread, that the charter was refused ; and the Albion Mill Company was accordingly constituted on the ordinary principles of partnership." Opposition to such undertakings was not confined to the British Isles, it being on record that when, after arranging (1779) for the provision of a Boulton and Watt pumping engine at Chaillot, Jacques Constantin Périer formed a company with the object of supplying Paris with water, powerful resistance was encountered. Stuart writing in 1829 describes how " a great outcry was raised by a party at Paris against its projectors, and notwithstanding the literary exertions, in its favour, of the celebrated Beaumarchais who had ventured some of his property in the speculation, it was completely borne down by its opponents, who were led on and stimulated by the ferocious and frantic declamations of the renowned orator, Mirabeau." Beaumarchais (Caron) had, of course, commenced life as a watchmaker and was a gifted mechanic as well as the author of " Figaro." Nothing however could arrest the general introduction of the rotative steam engine and thus we find James Watt remarking—in a communication prepared during 1814 for his friend Sir David Brewster—that the advantages of the double-acting rotative steam engine were such that " in most of our great manufactories these engines now supply the place of water, wind and horse-mills ; and, instead of carrying the work to the power, the prime agent is placed wherever it is most convenient to the manufacturer."

The " Autorail Rapide " and " The Talisman "

(*Contributed*)

WITH reference to the article entitled " Autorail Express Trains Between Paris and Zurich," which appeared in THE ENGINEER for June 7, 1957, the addition by British Railways of the fast steam-hauled train " The Talisman " to the service operating between London and Edinburgh allows a further comparison to be made. The booked times for " The Talisman " are :

	Down	
Depart	London (King's Cross)	4.00 p.m.
Arrive	Newcastle (Central)	8.28 p.m.
Arrive	Edinburgh (Waverley)	10.40 p.m.
	Up	
Depart	Edinburgh (Waverley)	4.00 p.m.
Arrive	Newcastle (Central)	6.15 p.m.
Arrive	London (King's Cross)	10.40 p.m.

It will be noted that 400 min are allowed for the distance of 393 miles (632·3 km) between King's Cross and Waverley, there being an intermediate stop at Newcastle. The booked inclusive average speed of both the up and the down trains is thus 58·9 m.p.h. (94·8 km.p.h.). Calculated to the intermediate stop at Newcastle the time allowed (north bound) is 268 min for the 268·5 miles (432 km) between King's Cross and Newcastle, the corresponding average speed being 60·1 m.p.h. (96·7 km.p.h.). It will be noted from the above-mentioned article that in the case of the " Autorail Rapide " the booked time for the journey Paris (Est) to Basel (S.B.B.) is 295 min and the distance 526km (327 miles), the corresponding inclusive average speed being 107 km.p.h. (66·5 m.p.h.), though there are as many as five intermediate stops. " The Talisman " is hauled by Doncaster-built steamlined " Pacifics " of class " RA9," with eight-wheeled tenders, a change of locomotive being made, in each direction, at Newcastle. The train consists of seven coaches having a total tare weight of 241 tons, seating accommodation being provided for sixty-two first-class and 174 second-class passengers. Since the weight of the locomotive and tender in working order is 165·3 tons, the total weight of the train is 406·35 tons, so that the approxi-

mate weight per passenger seat is 1·72 tons. The weight of the diesel-engine-hauled "Autorail Rapide" running between Paris and Basel is 191·5 tons, though this weight is reduced at Mulhouse to 79·9 tons by reason of the detachment there of three vehicles, including one of the motor coaches.

In connection with the runs from Paris to Basel and London to Newcastle, it is desirable that the comparison be based not on "The Talisman" of 1956, but on "The Silver Jubilee" of 1935, a train booked to leave King's Cross at 5.30 p.m. and to reach Newcastle-upon-Tyne at 9.30 p.m., with an intermediate stop at Darlington. The overall time of 4 h (240 min), corresponds with an average inclusive speed of 67·1 m.p.h. (108 km.p.h.). In the case of "The Silver Jubilee," the tare weight of the seven-coach articulated and streamlined train was 219·9 tons and the weight of the engine and tender in working order 165·35 tons, a total weight of 219·9 +165·35=385·25 tons. The train had seating accommodation for 198 passengers (78 first-class and 120 third-class), so that the weight per passenger seat was 1·94 tons. In the case of the five-coach "Autorail Rapide" —the vehicles of which are not articulated—tare weight is 191·5 tons, and as the number of passenger seats is 204, the weight per passenger seat works out at 0·94 ton, just 1 ton less per seat than in the case of the steam-hauled "Silver Jubilee." It is of interest to compare also the maximum axle load imposed by the respective trains. In the case of "The Silver Jubilee" (or "The Talisman") the maximum axle load is 22 tons (this being the load on each of the three coupled driving axles). In the "Autorail Rapide" the maximum load per axle is approximately 12·5 tons, though the average speed of the train (inclusive of five intermediate stops) is 107 km.p.h. (66·5 m.p.h.), comparing with 108 km.p.h. (67·1 m.p.h.) in the case of the steam-hauled "Silver Jubilee," which, however, made only one intermediate stop whereas there are five intermediate stops between Basel and Paris. As to gradients, the "Autorail Rapide" has much the hardest road, the climbs between Basel and Paris including the ascents to Champagney (altitude 1280ft); to kilometre post 303, near Chalindrey (altitude 1172ft), and to Chaumont (altitude 1033ft). Compared with these figures the altitudes reached on the line between King's Cross and Edinburgh (Waverley) seem insignificant. For example, the highest point reached by the railway between King's Cross and York is at Stoke, where, beside mile post 100 from King's Cross, the altitude is 345ft above sea level. On the section from York to Newcastle the summit is beside mile post 55 from York (between Darlington and Ferryhill), where the altitude is 292ft above sea level. Between Newcastle and Edinburgh the summit is reached at Penmanshiel, where, near Grantshouse, the altitude goes to 400ft above sea level. This is the highest point in the line between King's Cross and Waverley and it compares with the 1280ft (at Champagney) which is the highest point on the line between Basel and Paris. In connection with the important matter of axle load it will be noted that in the "Autorail Rapide" there is no very great difference between the axle load of the motor coaches and that of the trailer coaches, whereas in the steam-hauled "Silver Jubilee" the load on each of the locomotive driving axles is just twice the load on the vehicle axles. These figures illustrate that disparity between the axle load of the locomotive and the axle load of the trailing vehicles which has been described as one of the worst features of the steam locomotive. The figures are of the more interest in view of the virtually identical speed and passenger-carrying capacity of the trains compared. This is something of manifest importance to those responsible for the design and maintenance of the permanent way and structures over which such equipment must operate. (Note: it is appropriate to mention here that in the case of the 1200 h.p. high-speed, diesel-electric "Speed Merchant" locomotives lately introduced on the New York, New Haven and Hartford Railroad, the load per axle has been brought down to 10·4 tons (English). These locomotives are designed for a maximum speed of 117 m.p.h.).

A further matter on which comparison is of interest relates to the overall length of train as affected by the respective power units. In the case of "The Silver Jubilee," while the total length of the seven passenger-carrying vehicles was 392ft (over buffers), the addition of the length of locomotive and tender (70ft 3⅜in over buffers) brings the total length of the train to 462·25ft. As the number of passenger seats is 198, the overall length of the train per passenger seat provided is 2·33ft. For the five-coach "Autorail Rapide" the total length over buffers is 426·03ft and as the number of passenger seats is 204, the length per passenger seat is 2·09ft. It has to be remembered that "The Silver Jubilee" was made up of three sets of articulated coaches, whereas all the vehicles composing the "Autorail Rapide" are fitted with buffers, couplings and normal vestibules. Now that the steam locomotive is disappearing it may not be inappropriate to note how "The Talisman" is hauled by—among other engines of class "RA9"—"Silver Link," built at Doncaster Works in 1935. This was among the locomotives which worked "The Silver Jubilee" on its introduction during the same year, and we may note that twenty-two years ago the time allowed for the journey between King's Cross and Newcastle was 28 min less than the time allowed to-day, to say nothing of the intermediate stop (in 1935) at Darlington. This was with the same locomotive and a train only some 20 tons lighter. Not without historic interest is a further comparison which takes us back to the year 1603, when Sir Robert Carey made what is thought to have been the fastest pre-railroad journey from London (actually from Richmond) to Edinburgh. The occasion was the death of Queen Elizabeth I and we read how Carey, eager to be the first to intimate to the future James I that the Queen was dead, sat mounted on horse-back in the courtyard of Richmond Palace awaiting a sign from the window conveying to him that life was extinct. On receiving the agreed sign Sir Robert galloped off at once, intent doubtless on securing substantial favours at the hands of the incoming King. Since he is said to have reached Edinburgh in 60 h, Carey's average speed works out at 6·6 m.p.h., so that in the time taken by "The Talisman" to reach Edinburgh, he would have arrived at some point between Hitchin and Huntingdon. Incidentally, "The Silver Jubilee" in 1935 was allowed only 49 min from departure King's Cross to passing Huntingdon.

How to Build a Road

THE following is a brief abstract, which we give without comment, from a paper* presented by Mr. S. M. Lovell, county engineer and surveyor of the West Riding of Yorkshire, at the conference on the highway needs of Great Britain, held recently at the Institution of Civil Engineers.

What procedure has Britain evolved—at least, as far as major improvement works are concerned? For major improvement schemes the following items have quite often to be observed:

(1) Ministry request the local authority to prepare 1 (2) order details.
(2) Local authorities circulate appropriate authorities and other bodies (but not individuals) to obtain observations.
(3) Local authorities submit to Ministry draft order details.
(4) Ministry headquarters prepare draft order.
(5) Draft order placed on deposit (three months).
(6) Objections received by Ministry.
(7) Inquiry to discuss objections (if not resolved).
(8) Order made (if not amended by findings of inquiry—in which case matter reverts to item 1).
(9) Ministry invite local authorities to prepare land plans 14 (1) order details and scheme details.
(10) Local authorities send, in first place, 14 (1) order details to Ministry.
(11) Ministry headquarters prepare draft 14 (1) order.
(12) 14 (1) order placed upon deposit.
(13) Objections to (12) received by Ministry.
(14) Inquiry to discuss objections (if not resolved).
(15) 14 (1) order made (if not amended by findings of inquiry—in which case matter reverts to item 10).
(16) Local authority submits land plans to the Divisional Road Engineer of the Ministry of Transport.
(17) Divisional Road Engineer submits land plans to Ministry headquarters.
(18) Ministry headquarters submits land plans to chief valuer.
(19) Chief valuer forwards to district valuer. (The system of land acquisition hereon becomes a rather complex matter, involving Ministry—both headquarters and divisional road engineer, local authority, district valuer and, of course, all agents acting for interested parties—if no agreement can be reached the local authority and Ministry have to co-operate on the question of a compulsory purchase order.)
(20) Local authority forwards scheme details to Ministry.
(21) Ministry approve or amend scheme details.
(22) Local authority prepares draft contract.
(23) Ministry approve or amend draft contract.
(24) Local authority awaits clearance of land acquisition and authority to commence work.
(25) Ministry give clearance to item 24.
(26) Local authority advertise contract and receive tenders.
(27) Tenders to Ministry for approval.
(28) Ministry approve tender.
(29) Local authorities obtain committee approval to tender.
(30) Clerk of local authority prepares contract.
(31) Contractor commences work on site.

Can anyone be surprised if Britain appears to get "nowhere fast"?

* Paper No. 6, "The Suitability of the Existing Highway Organisation to Deal with an Expanding Programme of Road Construction."

Portable Powered Winch

A NEW portable powered winch developed by L. Hathaway, Ltd., of Oswestry, Shropshire, has the following overall dimensions:—Length, 30in; width, 22in, and height 20in. The approximate weight is 190 lb, and provision has been made in the design for staking in soft ground, bolting in a fixed position or chaining back to some form of anchor block. Power for the "Hathaway" winch is provided by a Villiers Mark 15 air-cooled, four-stroke, overhead valve engine, incorporating a kick start, and the drive is taken, via an automatic centrifugal clutch, by chain to an epicyclic reduction gear mounted inside the cable drum. This arrangement is compact and ensures that the engine cannot be stalled when in the engaged position the winch is fully controlled by the throttle. Supplied with the winch is 300ft of ¼in diameter hemp cored soft steel cable, and the unit can exert a pull of 1350 lb at 1ft per second. The speed can be increased to 3ft per second with the pull reduced to 350 lb.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

BLAST-FURNACE SLAG FOR CEMENT AND AS A CONCRETE AGGREGATE

SIR,—Please allow me to thank you and to congratulate you on the references to this subject in the leading article of your issue of October 25.

Although blast-furnace slag is being used increasingly for these purposes, we believe that insufficient interest and attention is paid to the economic advantages of using a residue material for cement and concrete. It is obviously wasteful to open up quarries in an unspoiled countryside to obtain raw materials, while piling up slag heaps by the wayside.

As regards the quality and suitability of the slag, the customer is fully protected by the following British Standard Specifications, viz. :

B.S. 1047/1952 : "Air-cooled Blast-Furnace Slag Coarse Aggregate for Concrete."

B.S. 146/1947 : "Portland Blast-Furnace Cement."

Substantial tonnages of air-cooled blast furnace slag have been used under B.S. 1047, and indeed the great new blast-furnaces of the United Steel Companies at Appleby Frodingham are laid upon a slag foundation. More recently, blast-furnace slag cooled by a water process, and known as granulated slag, has been extensively in demand for dam construction in the Scottish Hydro-Electric schemes—in the form of Trief cement. To-day the same material is being used to build the Avon dam on Dartmoor as part of the South Devon Water Board's conservation scheme.

F. W. VESSEY

London, S.W.1.

MOTOR SHOW AND SCREW THREADS

SIR,—I have noticed—rather late in the day, I fear—in your issue of October 25, on page 599, a small, though significant, point to which I would like to draw your attention. In the Table, under "Feature," there appear the entries "Unified threads throughout" and "British Standard threads throughout."

May I make the point, however, that the Unified is a British Standard thread, governed by B.S. 1580. I would suggest that what the Table calls "British Standard threads" would be more properly referred to as "Whitworth form threads." These thoughts are prompted by what I hope you will accept as a very natural reaction to anything which would make it appear that the Unified thread is in some way alien and not amenable to any of our national Standards. As you probably know, the Services and this Ministry are very much concerned with this thread, which is invariably specified for all equipment designed for Service use, and is warmly welcomed when it is found in ordinary articles of commerce which the Services use in considerable volume. The more it is adopted by industry generally, the easier will be any problems of maintenance of Service equipment bought "off the shelf"; further, it would seem that its adoption often puts a firm ahead of its less progressive competitors who continue to adhere to the traditional Whitworth form.

C. C. M. BELL

Ministry of Supply,
Standardisation (Munitions).
November 21, 1957.

Book Reviews

How to Become a Successful Manager. By HAROLD WHITEHEAD. George Allen and Unwin, Ltd., Ruskin House, Museum Street, London. Price 15s.

IN this book, written, as it is, in the first person, the important subject of management is handled in a refreshingly original manner, including the results of the wide experience of the author in this particular field, with some of the problems that confronted him, and how they were met. Dr. Whitehead, after being professor in the College of Business Administration of Boston University, returned to this country, where he had previously managed some businesses, to take up practice as management consultant, founding a company, while later he was industrial adviser to the Hungarian Government. Latterly he has been holding a few directorships and acting as adviser to boards of directors, and government departments.

Upper management is mainly in view, and a perusal of this book should be helpful to a managing director, who, in turn, might well pass it on to the more promising members of his upper staff. The necessity for making a good start is stressed, and two important lessons should be learned initially : (1) that self-criticism leads to balanced judgment, and (2) that each experience should teach something. Nobody can hope to be a successful manager unless he is blessed with common sense in no small degree ; indeed, a leading industrialist once affirmed that what he looked for in his upper professional staff was 10 per cent technical knowledge and 90 per cent common sense. The author puts it another way and would require 10 per cent technical knowledge and 90 per cent management ability. He further suggests that technical knowledge is not essential in a successful managing director, a statement which might well be challenged in the engineering world, although it must be admitted that if more attention had been paid to the humanities and a capacity to speak and write tersely and convincingly had been developed in early days, a man would be better able successfully to hold a high managerial post. In examining who have potentiality for management we are reminded that each individual is "a personality with hopes, fears, strength and weakness of character," and that consideration should be given to whether there are evidences of good judgment and a capacity for leadership. In the chapter entitled "Transfusion" the value of introducing new blood into an organisation is stressed, while the use of an expert consultant may bring fresh views before the administration. Keeping the upper management in the hands of a family circle may have disastrous results. In dealing at length with the subject of induction, the author speaks of the importance of seeing that when a new appointment is made the newcomer should receive a suitable welcome by being introduced to his new colleagues and staff, and his place in the hierarchy clearly defined. Certainly some of the main reasons for high labour turnover may be attributed to the neglect of proper induction. We agree that a policy of *festina lente* is advisable when it is a matter of a new chief reorganising a department. It is rather surprising to find that the use of an organisation chart or "family tree" appears to be deprecated on account of changing conditions normally encountered in most businesses, but surely the answer is that such charts should always be kept up to date, as they are in themselves valuable.

While the necessity for keeping management vigorous might appear to be axiomatic, there is ever a danger of an attitude of *laissez faire* creeping in ; a chapter is devoted to the best means of avoiding stagnation, largely the task of the managing director, whose daily job is usefully explored (the necessity for a sense of balance is alluded to, for while one overburdens himself with work that might well be delegated to subordinates, another refuses to "clutter his mind with details"). Dr. Whitehead devotes a chapter to getting a balanced board of directors, preferably low in numbers, each director having a definite function, while he concludes with the suggestion that "directors should save time (and patience) by keeping to the point in as few words as possible." The value of budgetary control is clearly demonstrated, but a warning is sounded that it takes a good three years before a budgetary control system can be established, and that the keystone to such a system should always be the sales budget, which in itself is dependent on ascertaining market needs, a subject to which a whole chapter is devoted. We are told that to assume that "the customer is always right" is frequently unwise ; indeed, he is more often wrong, not knowing what he really does want, and actually needs tactful education in the matter. Both market and marketing research are necessary if a reliable budget is to be produced. Because of the importance of ensuring a suitable sales budget and capitalising market opportunities Dr. Whitehead advocates the sales manager having a place on the board of directors. In summing up the position we read that "the managing director, by the full exercise of his responsibilities and opportunities, can give greater service to his country than any other calling," a statement which affords much food for thought.

In a postscript the author affirms that it is quite a climb to the managing director's office, and likens this climb to an obstacle race in which problems have to be solved and personal relations established, but, unlike the athletic race, day by day fresh obstacles have to be encountered. The following prayer was printed on a card and handed to each of Dr. Whitehead's students :—"Dear God, please make a swollen head as painful as a swollen tooth." We quote this because several successful business men have found it has a salutary effect, indeed a vice-president of a large corporation was able to produce from his wallet the little card given him thirty years previously.

Sir Cecil Weir, in a foreword to this book,

considers it will be as useful to those who have already achieved management positions as it will be to those aiming to get there, and in conclusion he hopes there will be a wide circulation to what he regards as "a useful and readable book on a subject so vital to our economy and to the advancement of those who have the urge to work for it"—an appreciation with which it is easy to agree.

Thermal Stresses. By B. E. GATEWOOD. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 56s. 6d.

WITH the increase of the operating temperatures in many fields of present-day engineering the subject of thermal stresses is becoming more important. A great deal of literature has been published on this subject, textbooks on fundamental theory, papers on particular problems, and so on. This author has covered, in under 250 pages, all phases of design problems at elevated temperatures. The subject matter being so large, and the book so comparatively small, it might be considered that the material would suffer from condensation. The author has overcome this by organising the material well and supplementing the main text by an excellent set of references at the end of each chapter. Worked examples are the feature of every section, and the author has set problems for the reader.

In the first chapter thermal stresses and simple applications are introduced before the general thermal stress equations are derived. This forms a store to which the reader is referred in later sections. The second chapter considers the all-important subject of temperature distributions, the first requisite of any thermal stress problem. The methods of heat transfer are fully discussed and supplemented by an excellent set of references. In the next three chapters the one-dimensional temperature and thermal stresses are discussed. Some of the simpler two-dimensional problems are dealt with, but the general theory is left until the last chapter.

The later chapters deal with the problems of material properties, allowable stresses and the efficiencies of materials at elevated temperatures. Thermal fatigue and thermal shock are also discussed. The author has presented and discussed these problems in great detail. Simple procedures are given to determine the approximate deflection and stiffness of a structure and the resultant effects on the thermal stresses and upon flutter. In the last chapter the energy and complex variable methods of solving thermal stress problems in two dimensions are discussed and applied to several problems.

The book is based on a series of lectures given to graduate aeronautical engineers and in the majority of cases the problems discussed are related to that field of engineering. In the early chapters, however, specific problems on nuclear reactor components and on turbine discs and blades are presented. While this book is for aeronautical engineers in particular, the problems of thermal stresses have been presented and discussed with a clarity which, with the excellent set of references, will make this book very useful to engineers in other fields.

General Workshop Exercises, Part I. By H. ROLLINS, M.I.B.E., and A. E. BELL, M.Sc., A.M.I.Mech.E. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 14s.

ONCE students have acquired a basic knowledge of workshop practice and the use of tools it is essential to hold their interest with practical exercises and, as is pointed out in the preface of this book, the demands upon an instructor of a large class are such that some students must inevitably lose time between steps in production due to ignorance of procedure. It is an aim of the book to provide guidance which will avoid this loss of time and possibility of the student's interest being lost by giving such detailed information on procedure that a student can carry on with a job in the correct sequence with only occasional supervision at the more intricate stages. At the same time the interest and the pride in craftsmanship of a student is held by basing the exercises on the making of tools for his own kit.

The book opens with concise notes on workshop techniques which are useful guides and reminders rather than for instructional purposes. Each of the nineteen exercises given opens with a sketch of the tool to be made, followed by actual drawings of the parts and notes giving the succession of operations to be followed in their manufacture.

In producing this book, it is stated, the authors have in mind the practical requirements of a three years' course to the standard of the intermediate certificate of the City and Guilds Institute in machine shop engineering, and it is intended to cover first year and the more elementary part of second year work. The intention is to publish a second book, covering advanced second and the third year work. Students and apprentices in their first year or so will find the book both useful and interesting, and instructors a handy supplement to their lectures.

Books of Reference

British Diesel Engine Catalogue. Published for the British Internal Combustion Engine Manufacturers' Association, 6, Grafton Street, London, W.1, by Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 52s. 6d. Edited by D. S. Dodsley Williams.—This is the fourth edition of the catalogue and opens with information regarding the British engine industry, notes upon oil engine working principles, definitions of technical terms, engine and fuel standards, cylinder identification systems, most of which are translated into French, Spanish, Portuguese and German. There is a lightning index, in which the engines are divided into five main groups and in order of horsepower, and which is of assistance in selecting suitable power units. The volume contains descriptions and tabulated information of some 2893 engines of forty-three makes. The manufacturers are arranged in alphabetical order and the section dealing with each make of engine contains descriptions, photographs and diagrams of the engines, together with tables setting forth the essential data while the engines are grouped into duty categories such as industrial, railway traction and marine.

Books Received

Engineers' Diary. Collins, 144, Cathedral Street, Glasgow, C.4. Price 5s. 3d.

Problems in Heat Engines. By A. J. Richmond. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 14s.

An Outline of Great Western Locomotive Practice, 1837–1947. By H. Holcroft. Ian Allan, Ltd., Craven House, Hampton Court, Surrey. Price 25s.

Data Book for Civil Engineers. Volume 2. Third edition. By E. E. Seelye. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 160s.

Mechanical Engineering Thermodynamics. By David A. Mooney. Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, London, W.1. Price 45s.

An Introduction to Operations Research. By C. W. Churchman, R. L. Ackoff and E. L. Arnoff. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 96s.

Design of Steel Structures. By E. H. Gaylord and C. N. Gaylord. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 60s.

Nuclear Chemical Engineering. By M. Benedict and T. H. Pigford. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 71s. 6d.

Technical Reports

The Application of Ergonomics to the Iron and Steel Industry. By R. G. Sell. Reports Nos. PE/N/79/56 and PE/N/80/56. British Iron and Steel Research Association, 11, Park Lane, London, W.1.—Control points in ten large steel works have recently been examined in detail by B.I.S.R.A., which has been carrying out ergonomic research for some years. The results are reviewed in the present report, issued in two parts.

It is recommended in Part I that the handles of master controllers should move in straight lines, in the same direction as the object controlled, and that the least number of notches should be used. B.I.S.R.A. experiments have indicated optimum arrangements for foot controls, the greater use of which is advocated. For continuous operation, such as in cranes and rolling mills, more wrist and arm movements are thought to be desirable than in, say, assembly work. Average operator heights, arm-lengths, &c., can be misleading, and the construction of adjustable mock-ups for test by a number of operators is advised. Standardisation and simplification of control layouts are recommended on psychological grounds. Indicators with more than one pointer are frowned upon.

There is no doubt, according to Part II of the report, that improvements in physical conditions of work increase productivity. Seats for crane drivers should, it is stated, fit correctly most of the men who will use them, and should allow movement to avoid fatigue. In conjunction with the Medical Research Council, B.I.S.R.A. has developed a fully adjustable seat claimed adequately to support the occupant's back. An often-overlooked point, says the report, is that sufficient space should be provided for an operator's legs and feet. Windows in crane cabs should be of fully toughened glass, not plastics or curved glass, and outside cleaning should be provided for. German cabs can be moved independently of the hook, enabling the driver to find the best vantage point; this was suggested several years ago by B.I.S.R.A., according to the author, but has yet to be adopted in British steel works. Aluminium sheet can reduce the radiant heat penetrating to an operator through opaque parts of cabs or pulpits. Extra panels of heat-absorbing glass can be placed outside windows, ventilated to ensure the dissipation of the heat rather than eventual conduction into the cab. Although expensive, air-conditioning is reported to improve efficiency considerably where heating problems are serious.

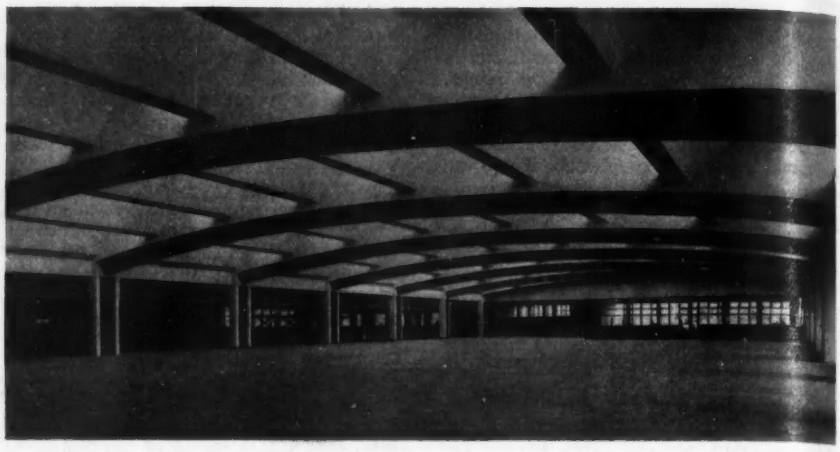
The Iron and Steel Industry in Europe. A study by the Iron and Steel Committee of O.E.E.C. Paris: The Organisation for European Economic Co-operation, 2, Rue André-Pascal, Paris (16e). Obtainable from H.M. Stationery Office, P.O. Box 569, London, S.E.1. Price 9s.—This report by the Iron and Steel Committee describing the situation in the iron and steel industry in O.E.E.C. member countries in 1955 was approved on November 29, 1955. The opinions expressed in it are based on statistical data for the first six months of the year, but in the main the conclusions reached have not been invalidated by developments during the subsequent six months. In particular, the forecasts for pig iron and crude steel production for the whole of the year have been borne out by the actual figures which are stated to have been as follows:—

Country	Pig iron	Crude steel
	Millions of tons	
Germany	16·5	21·3
Austria	1·5	1·8
Belgium	5·4	5·9
France/Saar	13·8	15·8
Luxembourg	3·1	3·2
Italy	1·6	5·4
Netherlands	0·7	1·0
United Kingdom	12·7	20·1
Sweden	1·2	2·1
Others (estimated)	0·4	0·8
Total	56·9	77·4

Transfer Function of a Steadily Diverging Reactor. By R. Potter. Atomic Energy Research Establishment, Reactor Division Paper, A.E.R.E. R/R 2245.—Knowledge of the transfer function is required for the design of automatic controllers (such as automatic starting systems) on diverging reactors. In this report general expressions are derived for the gain and phase shift of a steadily diverging reactor, expressed as functions of frequency. Numerical values have been calculated for a reactor with six groups of U^{235} delayed neutrons. "Doubling times" of one, five and twenty seconds, and mean neutron lives of 10^{-3}, 10^{-4} and 10^{-6} seconds have been considered, and results for these values are given graphically. It is shown that the transfer function of a diverging reactor is significantly different from that of a reactor in the steady state, the phase and gain margins being decreased. The additional margins required for stability can be found from the graphs.

Precast Concrete Factory Construction

Construction of a new cigarette factory for Gallaher Ltd., near Ballymena, Northern Ireland, is now well advanced. Two production halls of identical construction, giving close control of air temperature and humidity, absolute cleanliness and completely clear working space, were called for. One of the halls is 600ft long and the other 900ft long ; both are 105ft wide. There are no internal columns in either hall. Hollow precast concrete main beams span the full 105ft width. The beams are curved. They are simply supported at intervals of 30ft, and they carry a series of precast north-light shells, giving the interior appearance shown here.



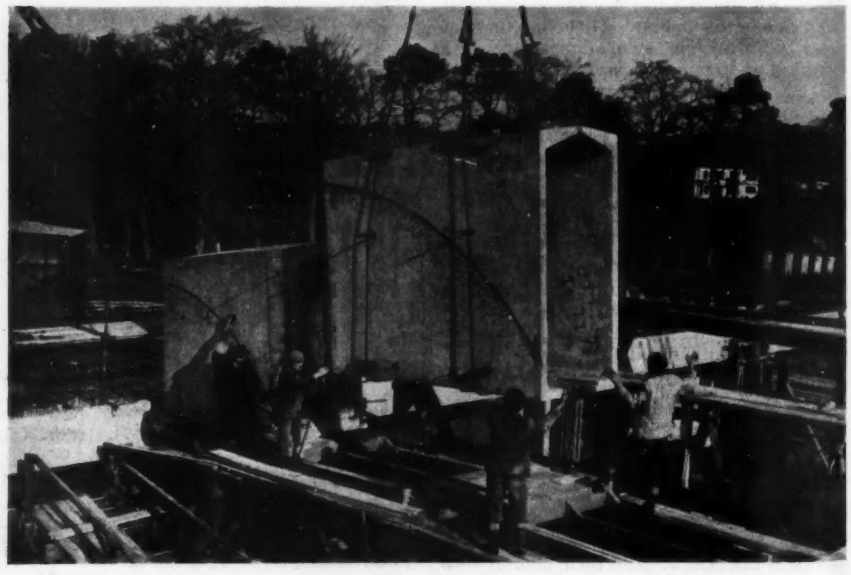
Air-conditioning ducts and other services are carried in the hollow main beams. Each beam is 9ft deep and 4ft wide and consists of seven precast box units, each approximately 12ft 8in long, and six intermediate diaphragm units, each approximately 2ft long, which are all prestressed together on the Gifford-Udall-CCL system by fourteen twelve-wire cables. The box units have 4in thick walls and are precast as two separate channels, each 2ft deep, mortared together by a simple butt joint at the top of the beam during erection, and bolted together until the prestress has been applied. The diaphragms have walls 9in thick and are precast in one piece.

Seven precast concrete north-light shells span between main beams, The rise of the shell is contained within the depth of the beam. Each shell unit is approximately 15ft wide, 3in thick, and weighs about 9 tons. Valley beams are precast separately and coincide with the diaphragms in the main beams. By placing the main connecting steel for the shell and valley beam units within the walls of the diaphragms it was possible to give the hollow box units of the beams a minimum wall thickness.

Erection of the production halls, which is repetitive, has proved particularly economical, we are informed. All the precast elements were erected by a 15-ton derrick. While a main beam is being erected and prestressed the derrick is able to reach over and position the shells and valley beams between the two beams beyond. A steel-frame stronghack is attached to the shells during lifting, as shown on the left, and temporary timber supports are fitted on the sides of the main beams at this stage. Joints are formed with rammed in situ concrete. A complete bay of the building, across the full width, is completed on average every nine days. Beam units are supported on a timber gantry as shown below until they have been mortared together and prestressed. The gantry is in four pieces, the two upper ones being able to slide inwards and downwards on the lower ones to free themselves from the beams after prestressing. The units are mortared together with a 1 : 1 cement/sand mix. Two days later the prestressing cables are threaded through the diaphragms and boxes of the beams and stress is applied. Concrete for the precast elements is a 1 : 4½ mix, giving an average cube strength of 8000 lb per square inch at twenty-eight days ; formwork is stripped after three days.

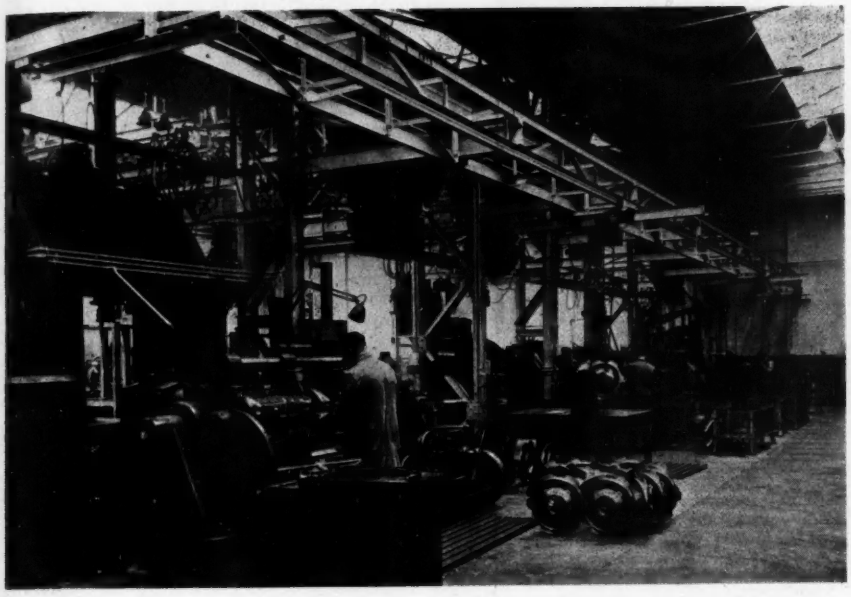
Cables are contained inside the main beam, seven against each side wall. In the hollow box units, the cables are exposed initially. In the diaphragms the cables are threaded through ducts in the side walls. Anchorages are in end blocks which are essentially specially strengthened diaphragms. After stressing, the cables are concreted solid with the wall of the box and grouted at the diaphragms. Complete cover is particularly important since the air in the beams will be continually almost saturated.

Expansion joints are provided at about 200ft intervals in the length of the halls. Each joint is formed by splitting the main beams in half longitudinally and the hollow columns in half vertically. To ensure that the beams will be completely stable until after the shell roof is in place, each beam is erected in the normal way, but with a wooden filler in place of the mortared butt joint. This wooden filler is also inserted during precasting of the diaphragms. After erection of the shells on either side of the beam, the joint is formed by knocking out the wood filler and cutting the reinforcing steel between the two sections of the diaphragms. Consultants, Sir Alexander Gibb and Partners ; contractors, Sir Alfred McAlpine and Son, Ltd.



Traction Motor Factory

A new factory for the manufacture of electric motors and generators for rail traction has been set up at Dudley Port by the General Electric Company, Ltd. It is a self-contained works equipped for all the manufacturing processes and testing except that the stampings are produced at the Witton works. The factory at Dudley Port has a floor area of 80,000 square feet and is laid out for flow line batch production with an output capacity of £1,000,000, rising to £2,000,000 of electrical machines per year. The main goods entrance leads to the stores and beyond it is the machine bay, which is equipped for all the machining operations required on the frames, end shields, armature shaft and commutator

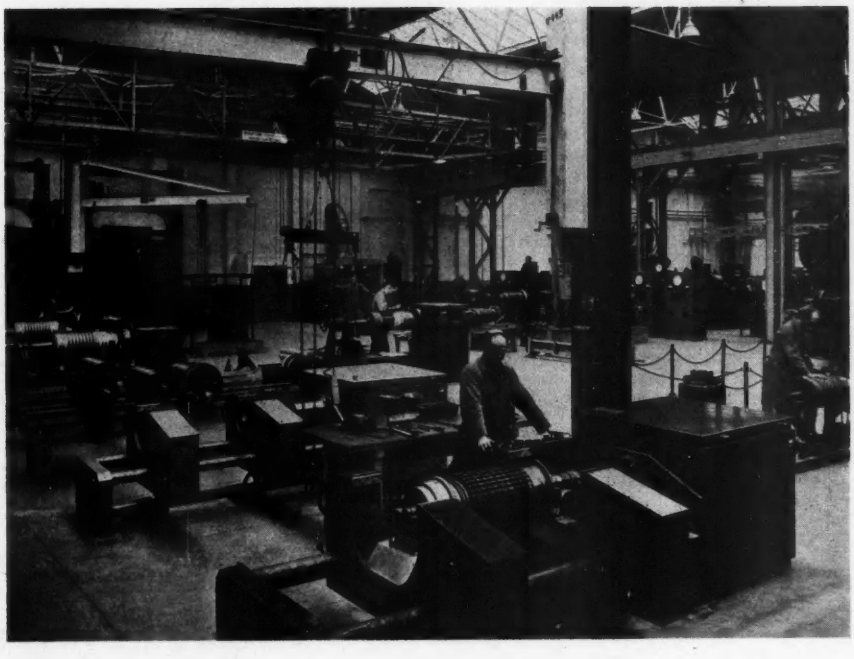


The view of part of the machine bay reproduced on the left shows the special monorail hoists for handling the parts to be machined. This system of hoist blocks, each with its monorail supported on brackets bolted to the main stanchions of the building, gives complete longitudinal and transverse coverage of the machine shop without encroaching upon floor space. Throughout the factory handling is facilitated by overhead travelling cranes and by jib cranes and by fork lift trucks.

To the right of the machine bay are the tool and drawing stores and the commutator building section; to the left are the areas for core building and commutator seasoning and finishing. There are two 100-ton hydraulic presses in the core building section. Beyond is a bay wholly devoted to armature winding and balancing and to the winding of field coils. At one end the armature coils are formed and insulated. At the other end of this bay are a number of dynamic balancing machines and fault testing sets. In the two armature balancing machines, which can be seen in the picture below, the amount and position of the weight required to correct any out of balance are indicated electrically on the instrument panel in front of the operator. The balancing and fault testing machines were developed in the G.E.C. Witton laboratories

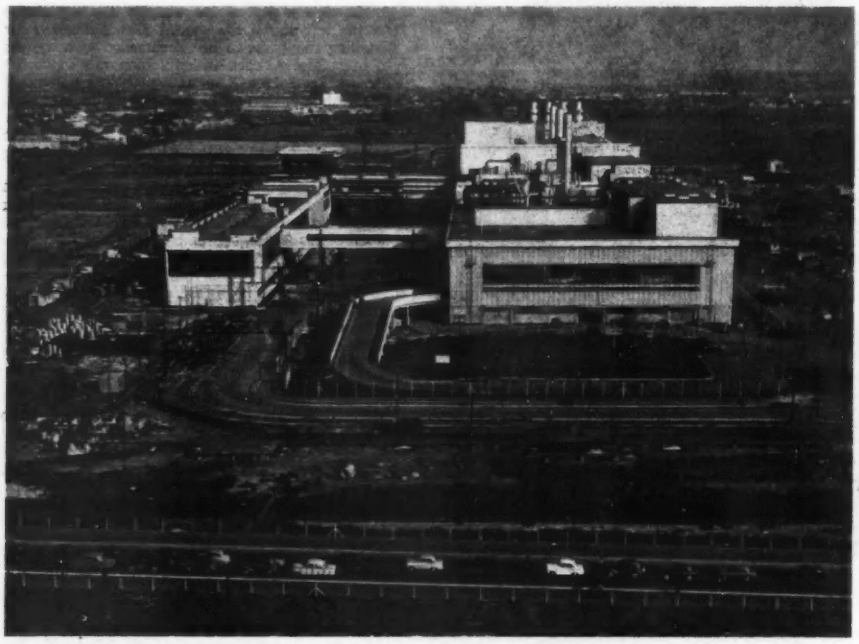
The test department, part of which can be seen in the illustration at the top of this page, is designed to handle a weekly output from the works of at least fifty main traction motors and the ancillary motor-generator and exhauster sets. Main generators up to 800kW for diesel-electric equipments can be tested here. There are four main motor test beds and each is equipped with its own forced ventilating air supply and test panel. Similar test beds are installed for the testing of auxiliaries. Power for the test beds is provided by four motor generator sets installed in the adjoining substation. Each set has a driving motor direct coupled to two generators, one of which gives a high-voltage output, while the other gives a heavy-current, low-voltage output. By using back-to-back connections for full-load tests, only the losses are required to be supplied from the motor generator sets, and the peak demand is limited to about 500kW. Power for the factory comes from the Midland Electricity Board's 7000V, two-phase, three-wire system, from which the supply is converted to 440V, three-phase, four-wire, by two Scott-connected transformers—one, of 6000kVA, for the works, and the other, of 800kVA, for the test department.

High-pressure hot water from two oil-fired boilers is circulated at 345 deg. Fah. to projector heaters, which are designed to maintain a temperature of 65 deg. Fah. in the works with an ambient temperature of 32 deg. Fah. and two complete changes of air per hour. Lighting is provided by 400W, high-pressure, mercury-vapour, fluorescent lamps, which give an intensity of 12 to 15 lumens per square foot on the working plane, with a total lighting load of 55kW



The Thames Foundry

An important part of the expansion programme which is being carried out by the Ford Motor Company, Ltd., is the Thames Foundry at Dagenham. This foundry, which will shortly be operating fully, has been built and equipped at a cost of about £8,000,000. It will function additionally to the existing foundry at Dagenham. The Thames foundry is planned for a daily capacity of approximately 400 tons of castings, or about two-thirds of the company's total output; the output for the most part will consist of cylinder blocks and heads and the larger castings for tractors. The main foundry building, which is shown in our right-hand illustration, is 1200ft long and 180ft wide. It accommodates the main foundry operations of melting, moulding, core-making and fettling



An ancillary building, seen on the left of the second illustration, measures 700ft by 60ft by 70ft, and is to contain the sand handling and drying, casting cooling, grinding and cleaning sections. The main building is a two-floor structure, the lower floor accommodating the maintenance equipment, offices, stores, locker rooms, showers and the canteen. The kitchen is equipped to supply hot meals for 700 men at a single sitting.

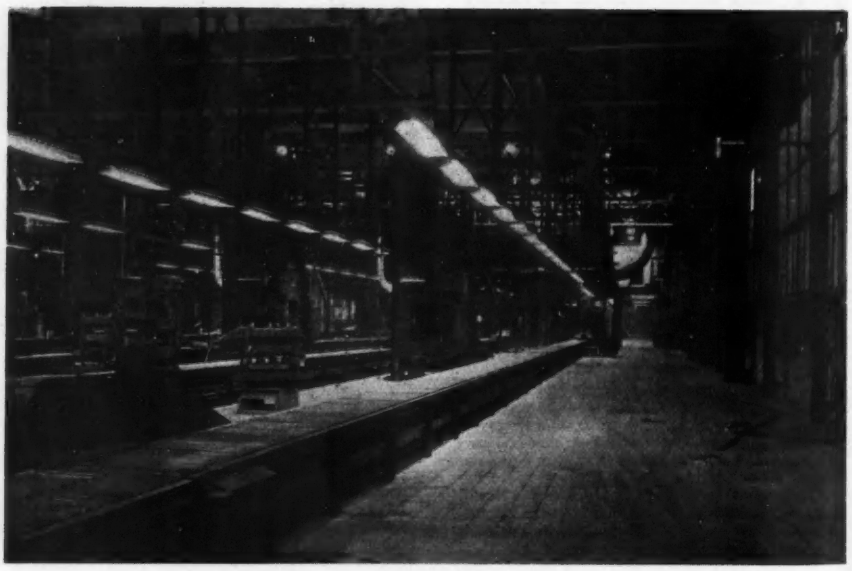
For the main operating floor, bays of 60ft by 60ft were selected as the design basis, and steel columns at 60ft centres support lattice girders, which form the fabric of the building. These girders are utilised for carrying much of the sand system and monorail conveyor equipment, and the material storage hoppers, thereby eliminating individual supporting columns and providing maximum free working space at floor level.

Throughout the foundry, there is provision for the best possible working conditions. The heating, ventilating and air-purifying system has been designed to warm the building and change the whole air content more than seven times an hour, and in the moulding and fettling departments as many as sixteen times an hour. There are steam heaters round the perimeter of the building and over the main aisles and doorways to compensate for heat losses. Dust extraction systems collect dust at the source and deliver it by ducting to wet separators. A sluicing system receives the slurry produced, together with slag from the cupolas, and carries it to settling tanks and ponds. The water is then returned for recirculation

The Thames foundry is fully mechanised, the power required for driving the equipment being approximately 15,000kVA; there are five sub-stations on the roof of the main building. Pig iron and coke are brought to the foundry in rail wagons, and there is a telpher system for lifting the containers from the wagons and conveying the coke to storage hoppers adjacent to the cupola melting units. The same telpher system will handle limestone.

Skip hoist machines load weighed charges of pig iron, scrap, coke and limestone into four 108in diameter hot-blast, water-cooled cupolas (two for each working shift), each of which has an 8-ton receiver for pouring the hot metal into ladles. The two moulding lines are fed from their own automatic sand systems and are equipped with smoke and fume collection apparatus. Each line includes eight semi-automatic moulding machines working within a continuous 800ft mould conveyor.

The fettling area, part of which is shown on the right, consists of eight lines for finishing and, if required, for water testing. The equipment includes two continuous cabinet cleaners, seven fettling conveyors, seven spot-blast cleaning machines, twelve water test machines, and ten gantry cranes with electric hoists.



Tractors at the Smithfield Show

The Smithfield Show and Agricultural Machinery Exhibition opens at Earls Court next Monday. This year some new wheeled tractors and at least one new crawler tractor of British design and manufacture will be prominent among the exhibits.

NEXT week, from Monday, December 2, till Friday, December 6, the Smithfield Show and Agricultural Machinery Exhibition is to be held at Earls Court, London. It is the ninth in the post-war series of Smithfield shows, and once again the greater part of the exhibition area will be taken up by a varied display of tractors and farm machinery and some of the equipment used in the meat trades. Traditionally, of course, the "Smithfield" is a Christmas fat stock show. The cattle exhibits continue to be an important attraction, but every year the first impression on entering Earls Court during the first week of December is that another large agricultural machinery exhibition has been staged!

This year, the chairman of the committee responsible for organising the exhibition is Mr. Lionel Harper, president of the Agricultural Engineers Association. At a luncheon in London last week, Mr. Harper spoke about some of the recent achievements of Britain's agricultural engineering industry, pointing out that, in addition to meeting the equipment needs of British farmers, the industry was now exporting tractors and other machinery to more than 100 countries overseas. Last year, Mr. Harper said, the industry's export total was over £70,000,000, and there was every indication that this year's figure would exceed £100 million; in the first ten months 95,618 tractors, valued at nearly £50,000,000, were sold overseas. It is particularly interesting to note that that figure included a number of British diesel tractors exported to the Eastern Provinces of Canada and to British Columbia.

The British agricultural tractor has long since grown out of the stage of being looked upon as not much more than a substitute for the draught horse. Farmers at home and overseas have now become keenly aware of the benefits to be derived from efficient power take-offs and hydraulic equipment. Tractor manufacturers, on their part, are finding an increasing demand for their products from industry outside farming. In earth-moving, trench digging and forestry work there is plenty of scope for a basically agricultural tractor and the equipment designed for operation with it. At Earls Court next week wheeled and crawler tractors covering an extensive power range will be on show. They will include some new models which have been announced in recent weeks. Superficially, the new tractors making their first appearance at the show may differ but little from those already established; but the refinements incorporated in their design are undoubtedly directed towards greater efficiency and versatility in operation. The newcomers, some of which are described here, emphasise that the tractor is indeed the farmer's "mobile power house."

The Fordson "Dexta"

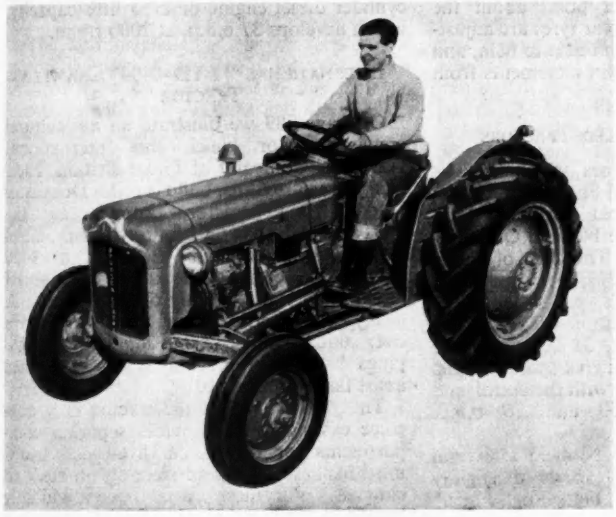
The "Dexta," which is the latest product of the tractor division of the Ford Motor Company, Ltd., Dagenham, Essex, is described as a "workmate" of the "Major," introduced six years ago. The diesel-engined version of the "Major" provides up to about 45 b.h.p.; the "Dexta" is rated at 32 b.h.p. The new tractor, it may be explained, is one of the first-fruits of the expansion programme which the Ford Motor Company, Ltd., is carrying out at Dagenham, an important item in that programme being the Thames Foundry, illustrated opposite, the equipment of which is now virtually completed.

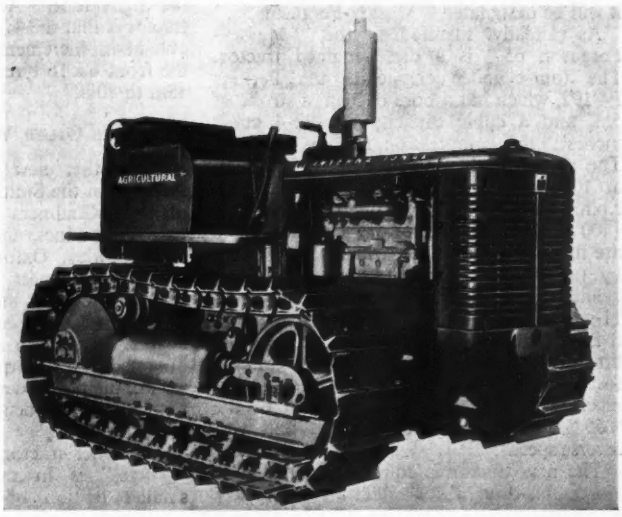
The engine of the "Dexta" is a three cylinder diesel, 3½in bore by 5in, with a capacity of 144 cubic inches; at 2000 r.p.m., the engine will give 32 b.h.p. Overhead valves are employed, operated by tappets directly from the gear-driven camshaft. The valves are located vertically in replaceable guides in the cast iron alloy detachable cylinder head and there are two springs per valve; to improve engine breathing, the inlet valve is larger in diameter than the exhaust valve. Cast iron gears, driven by the steel crankshaft gear, are used to drive the fuel injection pump and the camshaft. The in-line plunger fuel injection pump, which is flange mounted on the timing case, incorporates a pneumatic governor. Two-hole injectors locate directly in the cylinder head, on copper sealing rings. Throughout the engine, high pressure forced-feed lubrication is employed.

The gearbox fitted to the new tractor provides a choice of six forward and two reverse gear ratios, giving a forward speed range between 1·72 and 16·72 m.p.h. at an engine speed of 2000 r.p.m. There are two selector levers; the larger selecting three forward and one reverse ratio, and the smaller lever high and low ratios, thus doubling the number of reductions throughout the transmission system. An 11in diameter single-plate dry clutch is fitted to the tractors using a standard power take-off. But where a live power take-off is incorporated, a double clutch, with individual clutches to the rear wheels and power take-off, enables engine power to be disconnected from the rear wheels without interrupting the drive to the power take-off. A cut-away section of the gearbox with double clutch is reproduced overleaf.

A gear pump, which is mounted within the rear transmission housing and driven by the power take-off shaft, takes its supply from the transmission lubricant and delivers it under pressure to the hydraulic lift, the housing of which acts as a top cover for the rear transmission. The final drive of the tractor consists of a spiral bevel crown wheel and pinion giving a speed reduction of 6·66 to 1. The crown wheel and differential assembly is straddle mounted on taper roller bearings and the two axle shafts are splined directly into the differential side gears. The rear transmission housing extends forward, forming a compartment for the hydraulic power lift pump and ram cylinder. The power take-off drive is engaged by a lever, at the left-hand side of the rear transmission housing, which slides a splined coupling forward to engage with the hydraulic pump drive gear. The drive is then taken rearward by a shaft which emerges at the back of the tractor; the power take-off speed is 536 r.p.m. with the engine running at 1550 r.p.m.

The hydraulics of the new tractor are of the kind which gives a choice of two control systems, namely, "Qualitrol" or position control. The former is a method of selective





(Left) The Fordson "Dexta" has a three-cylinder diesel engine developing 32 b.h.p. (Right) The International Harvester "BTD-640" crawler tractor has been designed for agricultural use; its four-cylinder diesel engine develops 42 b.h.p.

depth control by implement draught, enabling work to be completed under constantly changing soil conditions and ground contours. Position control is a method by which an attachment to the tractor can be set at any required position and automatically maintained in that position irrespective of changes in soil resistance. In both systems, the main control is effected by a single lever which operates in a quadrant situated conveniently to the driver's right hand. The standard equipment of the tractor includes an "auxiliary service" control which is incorporated in the lift housing. It enables hydraulic power to be used for operating remote cylinders on such equipment as loaders or trailers.

The "Massey-Ferguson 65"

Massey-Harris-Ferguson, Ltd., Coventry, will show a new tractor at Earls Court next week. A year ago, it may be recalled, this firm introduced the "Ferguson 35" (THE ENGINEER, October 5, 1956), which is rated at round about 37 b.h.p. Now, the firm is putting into production at Coventry the "Massey-Ferguson 65," a diesel-engine tractor with an output of over 40 b.h.p. The Ferguson principles are embodied in the general design of the "65," just as they are in the "35"; this latter tractor will continue in full production, but from now on it will be designated "Massey-Ferguson 35."

As already mentioned, the "Massey-Ferguson 65" is a diesel-engined tractor. The four-cylinder engine is the Perkins P4/192, which has a bore of 3½in, a stroke of 5in, and a cubic capacity of 192·4 cubic inches; the compression ratio is 16·5 : 1. The rating of the engine is from 25 b.h.p. at 1000 r.p.m. up to 50·5 b.h.p. at 2000 r.p.m., with maximum torque of 136 lb-ft at 1400 r.p.m. Removable dry cylinder liners are fitted and the valves, which are operated by tappets from the camshaft, are in the cylinder heads. The fuel is contained in an 11-gallon tank situated above the engine; it flows through a sediment bowl to the fuel lift pump which forces it through the filters to the C.A.V. distributor pump fitted with a mechanical governor. The gearbox of the "65" provides for six forward and two reverse speeds.

The new tractor is equipped with 7in by 4in double-disc brakes which are completely enclosed. The differential lock is actuated by a spring-loaded foot pedal operated by the right foot. Another point about the tractor is that the 11–32 rear tyres are adjustable in 4in increments from 52in to 88in, and the front 6 × 16 tyres in 4in increments from 48in to 80in.

The "Massey-Ferguson 65" is fitted with a four-cylinder diesel engine developing over 40 b.h.p.

Some Other Wheeled Tractors

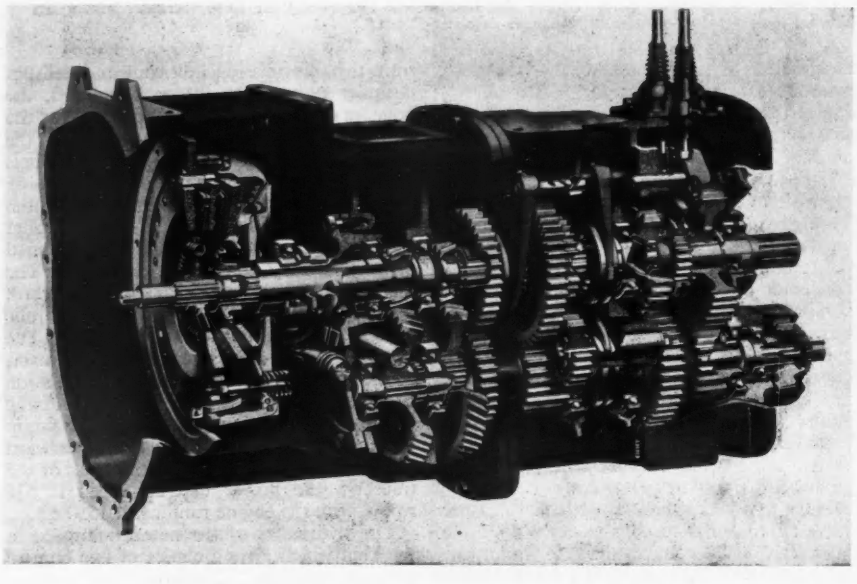
Two other new tractors which will be included in the Smithfield Show are products of Allis-Chalmers Great Britain, Ltd., Essendine, Lincs, and the Nuffield Organisation, Cowley, Oxford. The first of these, the Allis-Chalmers "D272," can be fitted either with the maker's petrol or t.v.o. engines or with a Perkins three-cylinder diesel engine. With the latter, 31 b.h.p. can be obtained at a governed engine speed of 1900 r.p.m., the power derived with the petrol and t.v.o. engines being 30 and 26 b.h.p. respectively.

The other tractor, the Nuffield Universal "Three," is in most respects a slightly smaller edition of the Nuffield "Four," which was introduced in 1949. The power unit of the "Three" is a B.M.C. three-cylinder diesel engine of 2·55 litre capacity, which develops 37 b.h.p. at 2000 r.p.m.

International "BTD–640" Crawler Tractor

On page 789 we illustrate an agricultural crawler tractor which the International Harvester Company of Great Britain, Ltd., has just started to build at its Doncaster works. The tractor, known as the "BTD–640," has a four-cylinder diesel engine which develops 42 b.h.p. at 1450 r.p.m. The engine follows the normal IH design, and starts directly on diesel fuel. A heavy-duty electric motor turns the engine over under full compression and "glow plugs" in the precombustion chambers assist fast warming up.

The main frame of the tractor is a one-piece casting which provides separate compartments for the clutch, five-speed transmission, bevel gear and steering brakes and clutches. All these parts are individually accessible for servicing without it being necessary to strip adjacent assemblies. There is three-point track suspension, which, it is claimed, allows the maximum track contact on rough ground, without distortion or strain. There are four bottom rollers and one top idler roller for each track, all of them being sealed against dust and mud. The track chains have interlocking link assemblies, with both the track pins and bushes passing through the front and rear of each link. The standard equipment of the "BTD–640" includes 12in track shoes with clipped corners, though larger sizes are available. The track shoes are keyed to the links by an extrusion which, the maker states, "absorbs much of the shearing strain normally placed on the track shoe capscrew." The tractor is said to be capable of exerting a drawbar pull of 9600 lb, in first gear, at a maximum governed engine speed of 1450 r.p.m.



Section of the Fordson "Dexta" gearbox with double clutch

INDIAN WATER POWER PROJECTS.—A booklet listing the principal statistics of the major water conservation schemes of India has been published by the Indian Ministry of Irrigation and Power. The principal statistics relating to each scheme and the dates of its construction are listed; most of the schemes are illustrated, but only brief data are given for those still in the planning stage.

Large Horizontal Milling and Boring Machine

A ram type horizontal milling and boring machine with a 10in spindle has been built by William Asquith, Ltd., Halifax, for the new B.T.H. factory at Larne. This machine weighs about 230 tons and its slide has a vertical travel of 15ft on the column which has a 33ft travel along the bed. Variable speed d.c. motors which drive the spindle, and the horizontal and vertical feed motions, are controlled by an electronic Ward-Leonard system incorporating a feedback tacho-generator.

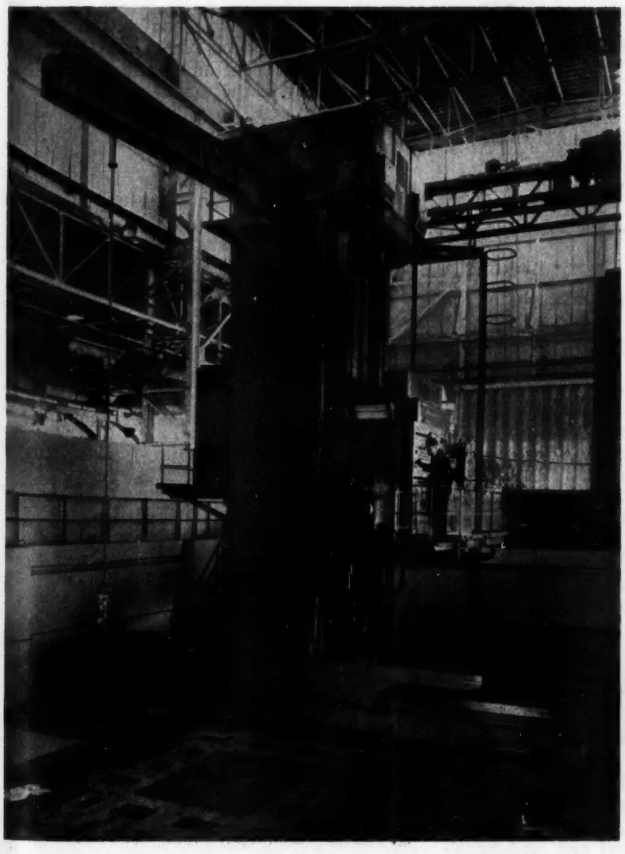
THE first of two very large, ram type, horizontal milling and boring machines for installation in the new Larne factory of the British Thomson-Houston Company, Ltd., has been completed at the Shrewsbury works of William Asquith, Ltd. This machine has a 10in spindle driven by a 50 h.p. motor. It is pointed out that if required a motor of double this power can be fitted but 50 h.p. is adequate for the milling requirements on turbine work at the B.T.H. factory. The spindle has a travel of 6ft 6in in the ram, which has a travel of 5ft in the slide. The main slide has a vertical travel of 15ft on the column of the machine and this column has a horizontal travel of 33ft along the bed. All of the motors and electrical equipment for the machine were supplied by the British Thomson-Houston Company, Ltd.

The new machine, as can be seen in the accompanying illustrations, has the main control panel on the slide and this panel is complete with push-buttons and dials for all motions. Adjacent to the panel are the change speed and feed gear levers and hand motion wheels for movement of the ram and spindle. Immediately below the panel are eyepieces for optical readings of the rates and verniers, which are fitted to all traverses; and this arrangement of telescopes, prisms and mirrors enable all readings to be made from a forward position on the operator's platform. All the movements are fitted with hydro-electric power-operated locks, and automatic lubrication of the slideways is provided.

Variable-speed d.c. motors provide the drives for the spindle, and the horizontal and vertical feed motions. By using this design of motor with a special system of gearing, mechanical gear changes have been eliminated in the horizontal and vertical feed movements, and in the spindle drive the number of gear changes is only four, to give a steplessly variable range from 1 to 300 r.p.m. Full power capability of the 50 h.p. d.c. motor at speeds between 1500 r.p.m. and 550 r.p.m., together with the four gear changes, gives full power at any spindle speed between 10 r.p.m. and 276 r.p.m. Below 550 r.p.m. of the motor, full torque is available but the horsepower decreases linearly with speed to an inching speed corresponding to 27·5 r.p.m. of the motor. The feed motors for horizontal movements of the column and for vertical movement of the slide are both rated at 20 h.p. between 1500 r.p.m. and 500 r.p.m., and they have a bottom speed of 37·5 r.p.m., to produce any variation in feed rate from 20in per minute down to ½in per minute, in each case. To ensure the shortest over-run following a stop during feeding, an electromagnetic clutch brake is incorporated in the gear drives of each of the feed motors in such a way that on stopping, the inertia of the motor is disconnected immediately by the clutch while the brake acts on the driven part of the gearing.

Because of the very wide variable speed ranges required of the d.c. motors and the necessity for speed to be held constant for any speed setting, despite fluctuations in load, the control of each motor is effected by an electronic Ward-Leonard system incorporating a feedback tacho-generator. Control is both by variation of armature voltage, and by weakening the motor field as the speed is raised in the constant power range of the motor. The motor armature is supplied by a generator which has its field excited from a thyratron panel; another thyratron panel supplies the motor field.

This form of electronic Ward-Leonard control has an additional advantage in that the speed and feed setting controls that the operator has to handle can be made very small, and grouped close together on a main control station built into the spindle gearbox. With it the acceleration and deceleration times are very small and the spindle and feed speeds may be preset and the motor accelerated up to the setting. This electronic Ward-Leonard feed control gives a steering control which permits simultaneous control of both the column and slide feed traverse motors. The spindle can thereby be made to feed in any direction in the vertical plane. A selection switch, a steering feed rate setting control and a direction setting control are located on the main control station. The resultant feed

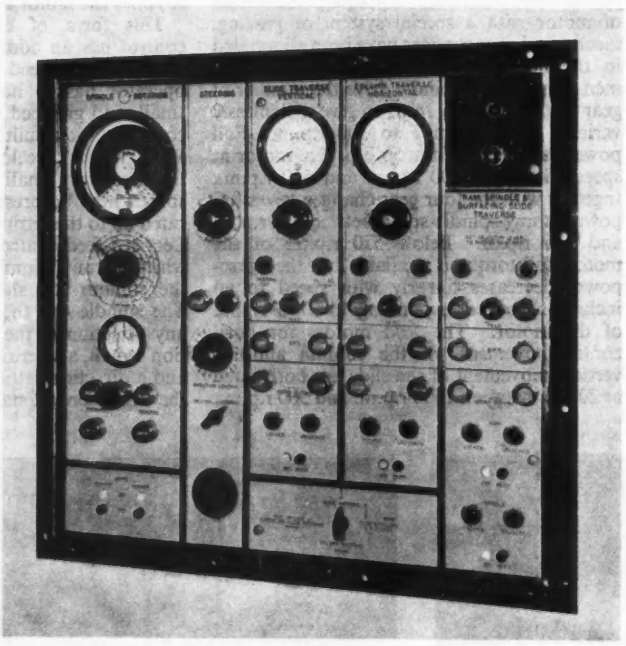


(Left) 10in-spindle ram-type horizontal milling and boring machine. (Right) Operator's platform and control panel with the ram extended a short distance

may be varied from 2in to 20in per minute and once set, remains the same whatever the direction set by the steering control.

The large-section ram mounted in the slide is provided with feed and quick power traverse motions, also means of micro-setting. The ram carries a milling sleeve mounted in precision ball and roller bearings which are arranged to take thrust loads as near as possible to the cutter, and the design is such that should a rise in temperature occur during a prolonged milling operation, the linear expansion does not affect the depth of cut. The milling sleeve has a 23in diameter flange at the front end on which milling cutters are mounted, and, if required, a surfacing slide attachment can be fitted to the front of the milling sleeve.

The spindle sliding in the milling sleeve can be extended to its maximum of 6ft 6in from the ram at any position of the ram. The rotation of the spindle is obtained from the milling sleeve and the same gearing provides the feeds for the spindle and the ram. Spindle or ram feeds can be used independently, but not together. A separate feed motor is not employed for the spindle and ram traverses, but instead power is taken from the spindle rotation motor via electro-magnetic clutches which enable either direction of feed to be obtained without reversing the direction of spindle rotation. Motion selecting levers on the spindle gearbox allow feed to be transmitted either to the ram, the spindle or a surfacing slide attachment when fitted. Twelve ram and spindle feed rates from 0·0083in to 0·10in per revolution of spindle are available. Hand motion is fitted for adjustment of the ram and spindle and for attachments mounted on the front of the ram if necessary. When the ram and spindle are traversed for screw cutting the feed motion electro-magnetic clutches are by-passed by a separate train of selected gears. A mechanical selection lever is used to decide whether the feed motion in this case is transmitted to the ram or to the spindle.



Main control panel on the slide of the horizontal milling and boring machine

Quick power traverse motors fitted for both the column and the slide traverses are rated at 30 h.p. and give a speed of 8ft per minute. On stopping this motion, d.c. injection braking reduces the over-run to about $\frac{1}{16}$in. For inching the column and slide 5 h.p. motors are used, and they give a traverse speed of 0·1in per minute. With the d.c. injection braking used the over-run when inching is stated to be about 0·0005in. The ram and spindle traverse motions are provided with common quick power traverse and micro-inching motors, which are rated 7·5 and 1 h.p. respectively. Selection of the motor drives to the ram and spindle is effected by levers on the spindle gearbox.

As already mentioned, all motions are fitted with electro-hydraulic locks. Four locks are used for the column, slide and ram traverses, while only one lock is used for the spindle. These locks consists of a screw which, on being turned, tightens a pad. The end of the locking screw is fitted with a vane which rotates in a hydraulic cylinder and oil at about 1000 lb per square inch is delivered on one side of the vane or the other to effect locking or unlocking. Automatic lubrication of the slideways and baseways is provided by a pump driven by a $\frac{1}{2}$ h.p. squirrel-cage motor, and flow switches in each oil supply line indicate correct oil flow, by lighting a lamp on the main control station. Each of the gearboxes used for column traverse motion, slide traverse motion and for the spindle and ram drives respectively is force lubricated by a pump driven by a 1 h.p. a.c. squirrel-cage motor.

The main control station, built into the spindle gearbox, can be seen in the photograph we reproduce. For each traverse motion it has a group of controls covering feed, quick power traverse, and micro inch. Another panel contains a motion selector switch that has an additional feature of permitting quick power traversing of both column and slide. Automatic unlocking and starting of auxiliaries is associated with the feeds and quick power traverse motions, and normally the lock and unlock buttons are left in the lock position. When one of the traverse buttons is depressed during a slight delay which occurs before movement commences, the motion first unlocks and, at the same time, lubrication and other auxiliaries are started. About four seconds after the traverse is stopped, the cycle is reversed and auxiliaries automatically shut down while the motion locks itself. During this four second period it is possible to restart a traverse instantaneously.

The steering controls are grouped and a switch on this panel section has neutral and steering positions. When in the steering position this switch makes push buttons for steering active, while all the other traverse push buttons are made inactive. After pressing the steering start button the unlocking and auxiliaries of both the slide and column traverses are started before movement takes place.

In addition to the speed and feed-setting dials, tachometers are provided on the panel for the spindle rotation and column and slide feed drives and an ammeter is provided to show the spindle load. Indicator lamps show whether motions are locked or unlocked and when feeds are taking place, and a "machine ready" lamp indicates whether the stop circuit is completed. Emergency stop buttons on the pendant and main control stations operate in this stop circuit and stop all motors. The spindle drive is interlocked with the feed drives and with the steering feed in such a way that the spindle must be running before a feed can be started. The push button controls on the pendant generally duplicate those on the main control station.

The electronic and contactor control equipment is housed in two groups of cubicles mounted on a platform near the foot of the column. The motor generator set and its equipment are situated at the back of the machine.

The attachments available with this design of machine include 2ft and 4ft diameter surfacing slides, which are bolted to the face of the milling sleeve and obtain feed and hand adjustments from the slide of the machine. A universal milling attachment and a right-angle head are available for bolting to the face of the ram. The milling spindle in these heads is driven by the milling sleeve or spindle of the machine. A 2-ton crane at the top of the machine column, directly above the ram face, facilitates the change-over of attachments.

Main Line Diesel-Hydraulic Locomotives

FIFTY-TWO main line diesel-hydraulic locomotives, each of 1000 h.p., have been ordered by the British Transport Commission from the North British Locomotive Company, Ltd., of Glasgow. These locomotives represent the first major instalment of a scheme for the complete replacement of steam by diesel traction on the whole of the Western Region lines between Newton Abbot and Penzance, including all freight and passenger services, and on many of the through trains between Paddington and Bristol and the West of England. The total number of diesel-hydraulic locomotives required for this programme is about 130, in replacement of over 200 steam locomotives. Fourteen diesel-hydraulic locomotives for the Western Region are already under construction or on order from the North British Locomotive Company or at the British Railways workshops at Swindon.

A substantial proportion of the remaining sixty-four locomotives required for the programme will also be built at Swindon, and they will be of a more powerful type for service in the heaviest passenger and freight workings between Paddington, Bristol and the West of England. All the locomotives ordered or to be ordered for this replacement scheme will be of diesel-hydraulic construction. The 1000 h.p. locomotives now ordered will have North British/M.A.N. high speed lightweight diesel engines with North British/Voith transmissions. The further sixty-four locomotives to be ordered will incorporate both M.A.N./Voith equipment and Maybach engines and Mekydro transmissions similar to those being installed in the locomotives now under construction at Swindon.

PROPERTIES OF PLYWOOD.—A concise account of the manufacture and properties of plywood, and of the various kinds of plywood commercially available and their uses, is given in a brochure published by the Timber Development Association. The brochure is intended as a comprehensive guide for users and designers.

Innovation in Land Drainage Methods

By A. N. EDE, M.Sc.

Here we abstract from a paper read before the Institution of British Agricultural Engineers on November 12. Our abstract is concerned principally with a description of a machine which forms concrete drains below ground level in a single operation. In the original paper the soil mechanics aspects of land drainage, an alternative machine using the vacuum concrete technique, and similar work in other countries, are all touched upon. This machine operates on the same general lines as a machine described and illustrated in THE ENGINEER *of December 9, 1938.*

THE cost per acre of an overall tile drainage system with drain lines spaced at one chain works out to be approximately £50, in spite of the use of highly efficient machinery. Some interesting methods involve special ways of introducing conventional tile-drains. In this country giant ploughs, tile-feeding devices, or the dragging or forcing in of lines of tiles into channels make a useful contribution in some conditions by cheapening a section of the overall expenses. However, even with rock-bottom material, labour and operating costs, tile drainage remains prohibitively high, although most important among the capital improvements on the farm.

A useful comparison may be made with the operation of mole-draining, in which an underground channel is formed in stable clay soil without the use of tubes. The contract price for mole-draining as closely spaced as two yards varies from 35s. to 60s. per acre, not inclusive of main drains. These comparatively low figures reflect the high work capacity of the mole plough in conjunction with negligible material costs. The twenty-fold cost disparity between mole-draining and tile-draining has led to the work on the use of mole ploughs for laying drains made from a cheap and readily available material—concrete. Consideration of conventional drainage methods shows several features on which improvement can be made.

(*a*) Trenching is a laborious and expensive way of introducing the drain ; (*b*) tile drains are moderately expensive to purchase and need considerable handling ; (*c*) a large quantity of permeable back-fill material is required ; (*d*) the operation of spoil replacement requires separate equipment ; (*e*) agricultural damage is caused by the movement of heavy equipment and by trenching operations.

There are certain obvious economies and benefits which a new method could make use of.

(*f*) The use of bulk-handled materials throughout ; (*g*) the elimination of separate soil-shifting operations ; (*h*) the combination of manufacture and placement of the drain ; (*i*) the provision of just sufficient permeable fill to conduct the water to the drain.

In respect of the drainage design data, it should be considered that : (*k*) control of ground-water level to the same standard may be obtained by a system of drains placed shallow and close or by a system placed deep and far apart. In the shallow case the drains need be less efficient as conduits ; (*l*) for heavy land drainage there is no evidence that deep drainage as opposed to shallow confers any benefit.

Basic Investigations on Concrete

In 1953 a small laboratory was completed at the School of Agriculture, Cambridge, for the Agricultural Research Council, for the investigation of drain installation problems, with particular reference to the use of mole ploughs and fresh concrete for forming and stabilising channels in one operation. Initially basic work was carried on in the laboratory only on the properties of fresh concrete. Information on the likely resistance to be met in forcing concrete through pipes, ducts and extrusion orifices was a basic necessity to the design of systems involving the passing of concrete through the narrow space allowed by the mole plough blade and for forming tubes *in situ*. The principal conclusion of this work is to place concrete in the freshly-mixed state into two groups, according to whether the volume of liquid in the concrete exceeds or is less than the volume of voids in the compacted mix. These two groups, saturated and unsaturated mixes, have distinct properties.

The saturated concrete handles well but is useless as received for the formation of a drain tube, but the unsaturated concrete, whilst adequate for direct use in tube formation, is not amenable to pumping. As an alternative method to pressure pumping was available, work was first concentrated on the latter material.

The main direction of material movement in a mole plough has to be essentially downward, and the use of vibratory action assisted by gravity has been studied. The vibration of the material itself merely serves to hasten consolidation and the development of lateral pressures within its container. The apparatus used to transmit concrete overcomes the adhesion and friction between the concrete and container by applying an intense vibration to the container, which is in the form of a long, flat, vertical duct. The concrete is unable to follow the movement of the container and is shifted downwards under gravity action.

The main concern is to achieve permeability in the drain wall of the same magnitude as in free-draining soils, and not with the low permeability figures which are met with in very dense concrete. By adjustment of

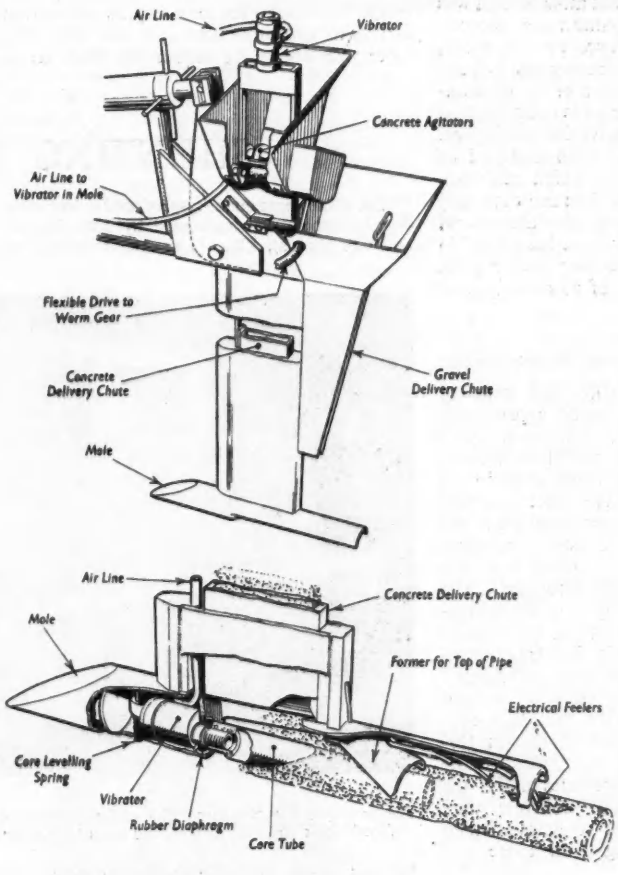


Fig. 1—Diagrams showing mechanism of plough and pipe construction

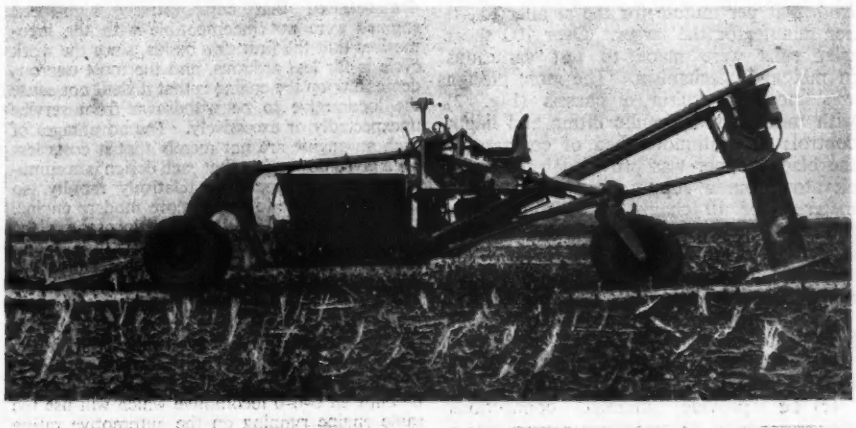


Fig. 2—Mole drainage machine, showing mole plough and concreting equipment

the mix proportions, principally by using aggregate with little or no fines, unsaturated concretes can be made to have permeabilities in excess of the objective of 0·01cm per second (14in per hour).

Field Tests

The need to estimate the forces acting on mole plough blades varying in dimensions from the normal size, and to control their action in various soils, has necessitated the development of a working theory. The precept of the theory is that the soil ahead of the mole plough is continuously thrown into a state of failure by reaction on the frontal surfaces of the blade and mole, and is sustained in this state until the blade and mole have passed by. By measurement of soil shear strength and soil/metal friction parameters, the drawbar pull on a blade of given dimensions can be estimated. To compare field results, an experimental mole plough was constructed with a dynamometer directly reading the horizontal force on the blade, which could be varied in dimensions by bolting on plates. A comparison of the theoretical and measured drawbar pulls indicates that the theory gives reasonable working estimates. By use of it a blade has been designed of section 1½in by 18in, a size which can work with certainty at depths of 30in in heavy clay soils and up to 48in in lighter alluvial soils and loams. These dimensions have been fixed in the relation to the 20,000 lb drawbar pulls available from a number of commonly-used heavy tracklayers.

The Vibration Method of Drain Laying

The design data on soils and concrete enabled the initial tube laying experiments to go forward. The mole plough was adapted by fitting a hollow welded steel blade housing internally a pneumatically vibrated feed duct of section 8in by ¾in. The duct connects from a small hopper fitted with agitator to the mole channel (Fig. 1).* Concrete emerging from the duct comes into contact with the core around which the tube is formed. The core itself is vibrated axially by a small high-frequency pneumatic vibrator in the nose of the mole. The concrete is first fragmented and settles to the exposed floor of the channel. The supply proceeds progressively to build up the walls and roof of the tube in a continuous process as the machine moves forward. Finally, a roof plate presses the material down as it consolidates under the continuing vibration. The concrete then becomes a self-supporting structure, which can resist minor buffeting from loose soil as the core moves away.

With this machine 4in outside diameter tubes with inside diameters from 1½in to 2¾in have been placed at speeds varying from 34ft per minute for the smaller to 4ft per minute for the larger. Over 100 short trial runs were made to test variations in mix and mechanism. The mole plough was mounted within a chassis (Fig. 2) with means for hydraulic lifting and depth control; a continuous feed of concrete to the blade hopper was provided by a screw elevator from a supply hopper containing material for 10 chains. An addition to the blade consisted of a slit back-filling hopper, by which ⅜in gravel could be deposited as a continuous sheet above the tube. The functions of the gravel are:

(*a*) To prevent slit closure in heavy soils from distorting the channel.

(*b*) To form lasting connections in heavy soils for mole drains, surface run-off, &c.

(*c*) To provide indirect connections between minor drains and main drains by means of the intersection of gravel sheets.

(*d*) To ensure a large effective drain size in ground-water situations.

In addition to isolated test lengths, drains were laid down in 1956–57 in soils consisting of fen peat on clay, heavy gault clay (two schemes) and in heavy silt. Initially, haulage was arranged by use of a tractor-mounted winch and cable. Later it was possible to use a heavy tracklayer for direct haulage. A reduction gearbox provided a governed speed of 8ft per minute. Experience gained with this tractor enabled changes to be made for more convenient field handling. The machine was shortened, the mechanical feed system and supply hopper dispensed with, and hoppers were provided at the rear astride the blade for hand feeding of both gravel and concrete. In this semi-trailed form manœuvring is simple, and one operator can handle the steering, depth control and supply. Use of the machine to lay long lengths has proved satisfactory for tube sizes up to 2in internally. Core sizes above 2in require the blade to be withdrawn at intervals for cleaning, as the present mole and core arrangement has not been developed to give a vigorous enough scour on the core surface.

Economy

The cost of the technique has been assessed on the basis of capital charges, depreciation, running costs, labour, replacements and materials charges on a yearly, hourly and footage basis. For periods of work in the region of a likely annual work period of 450 hours the cost per chain and per acre for overall drainage is as follows:—

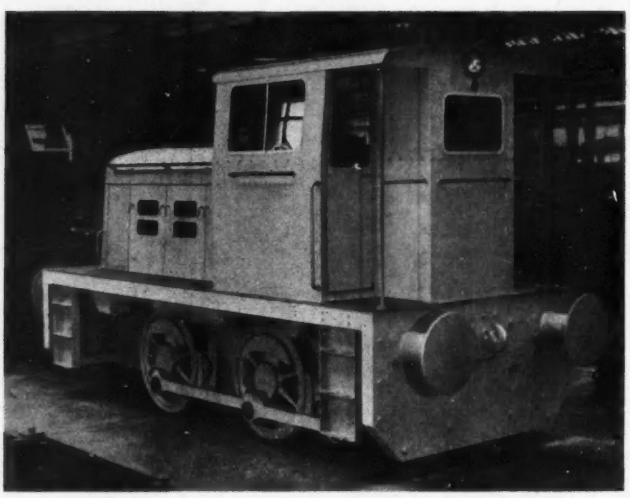
Speed of work, ft/sec	Linear cost pence/ft	£/chain	Area cost, £/acre Spacing (chains) 2	1	1/3rd	1/10th
0·1	4·30	1·18	8·5	14·4	38·0	121
1·0	1·35	0·37	2·7	4·5	11·9	38

With the present vibration equipment the speed is somewhat better than 0·1ft per second, and allowing the expense of 2s. 6d. per chain for sheet gravel backfill, the overall cost can be estimated at 25 to 30 per cent of the cost of conventional work.

* The diagrams are the copyright of *Farm Mechanisation*.

SHUNTING LOCOMOTIVE

FOR some years quantity-produced automotive oil engines have been used by John Fowler and Co. (Leeds), Ltd., in crawler tractors, the Leyland O.600 in the "Challenger III" and the "Comet" O.350 in the "Challenger II," and they achieved overhaul lives of the order of 10,000 hours on earth-moving duties. This demonstrated that comparatively high-speed engines were not incompatible with the locomotives that the firm also builds, since the work cycle is far less arduous, and the most onerous demand upon the engine is that it shall not cause the locomotive to be withdrawn from service unexpectedly or excessively. The advantages of such an engine are not merely that it costs less for a given power, but that each design is accumulating service experience relatively rapidly, so that it is possible to buy a more modern engine.



The prototype 176 h.p. locomotive under construction: the cab affords a view of both front and rear buffers, and gives shelter for a shunter riding outside

For its latest 0–4–0 shunting locomotive the firm has adopted the largest engine in the Leyland range, the EN.900 of 926 cubic inches, which was described in THE ENGINEER of January 18, 1957. The application is conservative in that, instead of the customary one-hour rating, the engine is run on the rack setting of the twelve-hour rating (194 h.p. at 1700 r.p.m.) and is governed at only 1500 r.p.m. It is anticipated that there will later be built an 0–6–0 locomotive which will use the same engine running on the automotive rating equivalent to 230 h.p. at 1900 r.p.m.

The engine is bolted solidly to the frame and its Fluidrive coupling drives by means of an open cardan shaft a Self-Changing Gear four-speed box on the front of the final drive. The main box has ratios of 4·08, 2·35, 1·49 and 1:1; reversing is by dog clutches connecting either of the two bevel crown wheels to the output shaft. Double reduction gears carry the power to the jackshaft; transmission efficiency is assumed to be 80 per cent in all gears. The final drive on production locomotives will be a standard pattern supplied by Alfred Wiseman, Ltd. Two final drive ratios will be available, giving governed speeds in direct drive of 14·5 and 13·1 m.p.h., corresponding to tractive efforts of 3660 lb and 4030 lb, and ratios of adhesive weight to maximum tractive effort of 4·18 and 3·8, respectively; estimated loads behind the locomotive are 720 and 800 tons on straight and level track.

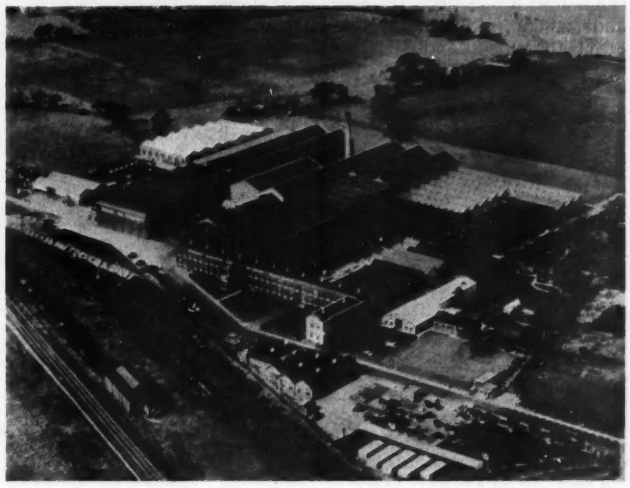
The construction of the locomotive follows conventional lines; plain bearings are used on jackshaft and axles, and automatic lubrication is optional. All services are pneumatic and operation of the forward/reverse cock alters the head/tail lamps and the selection of sanding pipe. (Sanding pipes are outside the wheelbase.)

Leading Particulars

Type	0–4–0
Weight in working order (in tons of 2240 lb), approximately	28
Wheelbase	5ft 6in
Radius of sharpest curve easily negotiable	60ft
Diameter of driving wheels	3ft 6in
Minimum weight of rails, pounds per yard	75
Height overall	11ft 3in
Overall length (including buffers), approximately	20ft 10in
Overall width	8ft 5in
Fuel tank capacity	70 gallons

The prototype was demonstrated to us last week and at light duties was notably quiet, though with a slightly black exhaust under full torque at low engine speed. Gear engagements appeared to be abrupt, but this was observed on the first day that the locomotive had been run under its own power. It is anticipated that production locomotives will be the least costly available in this country.

Fifty Years of Diesel Engine Development



Fifty years ago the diesel engine manufacturing company of Mirrlees, Bickerton and Day, Ltd., was formed. Since then many improvements have been effected in engine design and new engines have been introduced while manufacturing capacity has steadily increased. These trends have been particularly marked since 1946, and in the last ten years the plant and the number of employees have been doubled and the output quadrupled. The works at Hazel Grove, Stockport, of which we reproduce an aerial view, now occupy an area of nearly 8 acres.

THIS year marks the Golden Jubilee of the establishment of the diesel engine manufacturers, Mirrlees, Bickerton and Day, Ltd., at Stockport, for it was in 1907 that the company was formed by Mr. C. Day in association with Mr. N. H. Bickerton, of the National Gas Engine Company, Ltd. Land was acquired at Bramhall Moor Lane, Hazel Grove, Stockport, Cheshire, and in August of the following year the factory came into operation, being engaged in the production of diesel engines with a power range from 50 to 750 b.h.p.

While the works at Stockport has been building oil engines for fifty years, the company had been engaged on the manufacture of oil engines for some ten years previously. It was in 1897 that an engineering company (which was founded in 1840, to manufacture cane sugar machinery and in which eventually Mr. J. B. Mirrlees became a partner) after investigating Dr. Diesel's design patents acquired an exclusive manufacturing licence for such engines in Great Britain.

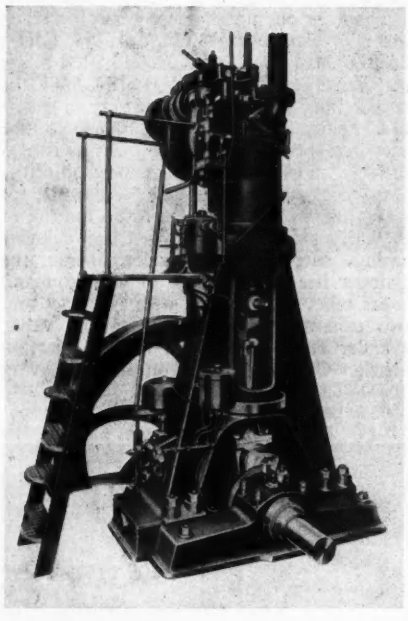
Within a few months an engine was built and was undergoing tests at the Royal Technical College, Glasgow. This four-cycle, air-injection unit, shown in our illustration and stated to be the third diesel engine to be built in the world, had a single cylinder of 300mm diameter by 460mm stroke, and developed 20 b.h.p. at 200 r.p.m. After the completion of extensive testing the engine was on regular service on the company premises and to-day can be seen in the Science Museum, South Kensington, London.

This pioneer effort in diesel engine building produced a unit which has proved to be the first of a long line of engines which have been steadily improved in design and performance.

The power range has been extended to over 4000 b.h.p., and the engines now manufactured at Hazel Grove provide power for ships for both main propulsion purposes and for auxiliaries ; for a wide range of industrial applications ; for traction purposes, and for the generation of electricity.

Six years after the completion of the first engine, orders were received from the Admiralty for two four-cylinder engines, each of 160 b.h.p., for powering generator sets to be installed on board the battleship H.M.S. "Dreadnought." This was the first diesel power unit fitted in a British warship and proved itself to be the forerunner of the many similar units to be used by the Navy for auxiliary purposes during the ensuing years. Development was stimulated by this Admiralty interest and in 1906 the company designed a four-cylinder, light-weight unit, of 120 b.h.p. at 400 r.p.m., intended for pinnace propulsion. It was the demand for diesel engines in those early years that influenced the decision to form a new company and to build a works specifically equipped to produce diesel engines.

In the four years preceding 1912, when Dr. Diesel's major patent expired, a number of designs embodying various sizes of bore and stroke, and an extended range of output, were introduced. Thus the company had established itself in a strong position when new companies entered the market. During



The first British Diesel engine, built in 1897, had a single cylinder developing 20 b.h.p. at 200 r.p.m.

the first world war the company introduced electrical and mechanical devices for controlling air blast injection pressures according to the load on the engine, the floating gudgeon pin and the first alignment indicator for lining up crankshafts. A new crosshead engine, having a bore and stroke of 21½in by 24in, water-cooled pistons and a rating of 166 b.h.p. per cylinder at 200 r.p.m., was produced in the early years of the next decade and was followed by a "hot bulb" or semi-diesel engine. This operated at a lower compression than the full diesel and was of single-acting, crosshead, two-stroke design, utilising the varying volume between the top of the crosshead guides and the underside of the piston as a scavenge pump. The engine had a bore of 12in by 13in stroke, a rating of 40 b.h.p. per cylinder at 325 r.p.m., and was subsequently redesigned as a full compression-ignition engine.

In 1925, "Nobel" two-stroke engines of 22in by 30in bore and stroke were built under licence, and in 1927 a Mirrlees engine of 8½in bore by 12in stroke was run at 450 r.p.m., a speed which was later increased to 600 r.p.m. to give an output of 33 b.h.p. per cylinder. Subsequent to 1930 airless injection gradually superseded the air injection system and the company incorporated the Ricardo sleeve valve and Comet head combustion chamber in certain engines. There followed the "H.F." design, which had a rating of 110 b.h.p. per cylinder when naturally aspirated and 165 b.h.p. when turbo-pressure charged.

Almost immediately after the end of the second world war, the company became members of the Brush Group and there was considerable reorganisation and expansion. The Mark II version of the "T.L." engine and incorporating four valve cylinder heads, was introduced in 1947 and two years later development work was put in hand on the "J" and "K" series of engines. These were designed as four-stroke, single-acting, airless-injection units in two cylinder sizes, and made available as vertical in-line or vee engines, with provision for turbo-charging and air intercooling. The "J" engine has a bore of 9¾in and a stroke of 10½in, and is available with from three to sixteen cylinders to give a power range of 111 b.h.p. at 400 r.p.m. to 2272 b.h.p. at 900 r.p.m. When naturally aspirated the brake mean effective pressure is 94 lb per square inch, and this is increased to 160 lb per square inch when turbo-charged with intercooling. The larger "K" engine has a bore and stroke of 15in and 18in respectively, and an output range from 192 b.h.p. at 200 r.p.m. to 4128 b.h.p. at 428 r.p.m.

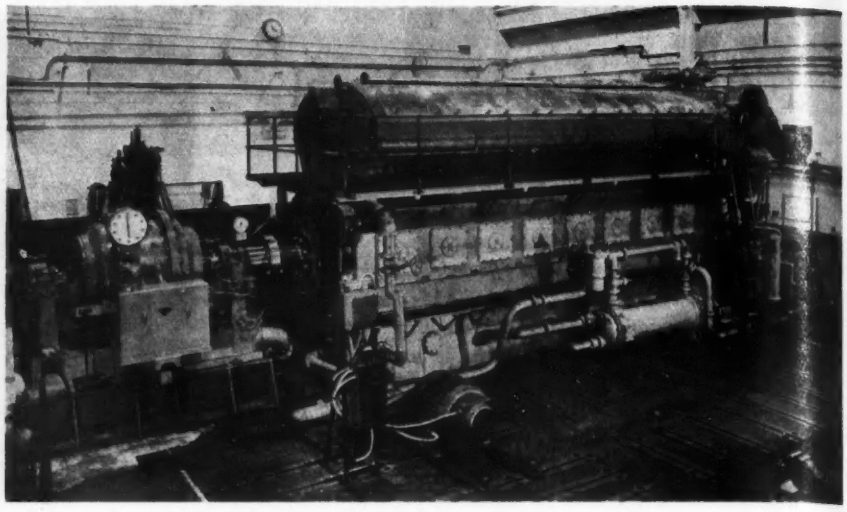
The passing years, with their steady expansion of diesel engine building activities, have concurrently called for improved facilities, more factory space, new machine tools and great expansion in personnel. To-day, the factory, which stands in the midst of 250 acres of land, has a shop floor area of about 320,000 square feet and employs about 1700 men.

The post-war period, with its strong international competition, and economic conditions imposed by world trade, has made it essential to examine carefully manufacturing methods and to

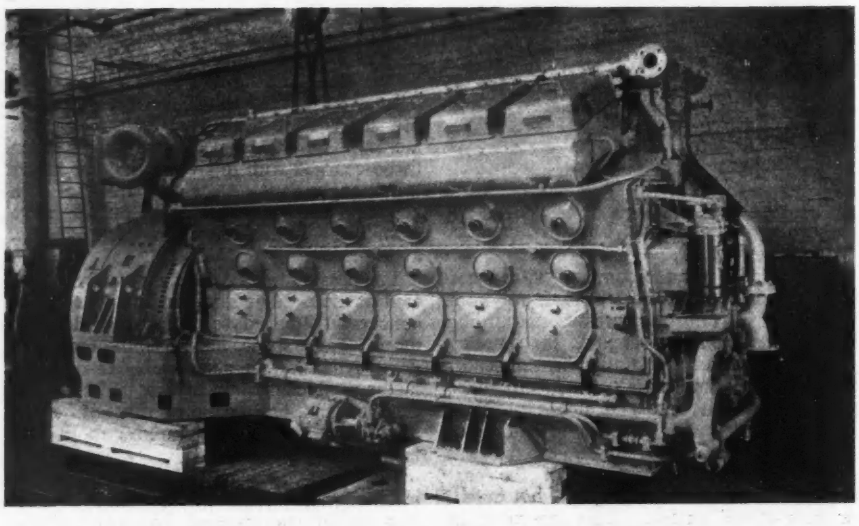
rationalise production. Planned production and standardisation were also necessary to offset the greater costs of raw materials, higher wages and shorter working hours. These problems have received attention and progressive replacement of machine tools has been carried out, so that the most modern equipment is available for heavy oil engine production. In addition, there has been considerable reorganisation within the works, including extensions to shops, resiting of machines to expedite the various operations in conformation with schemes of planned production. Some account of this work appeared in THE ENGINEER of February 6, 1953.

At the invitation of the company we attended a luncheon to celebrate the Golden Jubilee of its foundation, and Mr. I. T. Morrow, the chairman, in the course of his remarks, made at the luncheon, recalled some of the highlights of the company's history. He went on to say that in the last ten years the plant had been doubled and also the number of employees, while the output had been quadrupled. About £1,750,000 had been expended on special tooling, and Mr. Morrow referred to some of the recent work carried out, such as the power supply for the Jodrell Bank telescope, the diesel-electric locomotive for British Railways (described in our issue of November 8) and electrical generating stations for the Middle East. The company, he went on, exported 77 per cent of its production either directly or indirectly without the benefit of any protection by tariffs. Sir Roy Dobson, the deputy chairman of the Brush Group, also spoke, and, after remarking that the companies forming the group were largely autonomous, he called attention to the opportunities for export presented by the Canadian market, where power was required for steel works, mines, rolling stock and numerous power generating schemes.

After the luncheon, a tour was made of the works to see something of the equipment, layout and current production. The AIA–AIA diesel-electric locomotive was available for inspection and we illustrate the power unit which is a Mirrlees Mark JVS.12.T engine of 1250 b.h.p. at 850 r.p.m., coupled to a Brush generator of 823kW. Also on view was the 1897 engine, on loan from the Science Museum, and the first of the Mirrlees Mark KV.SS 16 engines. This engine was unveiled by Sir Roy Dobson, and then started by him, and another interesting ceremony performed by Sir Roy was the presentation of gold watches to fifteen employees who had started work with the company between 1907 and 1914. The KV.SS 16 four-stoke, direct-injection, exhaust turbo-charged and intercooled engine, illustrated above, has sixteen cylinders arranged in two banks of eight, set at an included angle of 45 deg., and the KV engine can also be supplied naturally aspirated or exhaust turbo-charged. The governed speed range is from 300 to 428 r.p.m., and the corresponding horsepowers for each form of engine are 1552 to 2208 b.h.p., 2432 to 3456 b.h.p., and 2880 to 4128 b.h.p. respectively. The bore is 15in and the stroke 18in, and the scantlings are in excess of Classification Society's requirements. The cast iron bedplate is in one piece as is also the column which forms the upper half of the crankcase, and carries the camshafts, of which there is one per bank. To the top of the column are bolted the cast iron cylinder casings carrying the cylinder liners; the cylinder heads, which are of cast iron and stress relieved, are fitted with two inlet and two exhaust valves, an air starting valve, cylinder relief valve, and a fuel injection nozzle. Oil-cooled, cast iron pistons, having three pressure and two oil scraper rings, are employed in association with "H" section forged connecting-rods of B.S. En.8 heat-treated steel and having white-metal-lined big-end bearings and small-end bearings of phosphor-bronze. The crankshaft, a B.S. En.8 steel forging, is carried in white-metal-lined, steel shell bearings. Starting air pressure is 300 lb per square inch, the cam-operated fuel injection pumps are arranged so that the length of pipe to each injector is identical, pressure lubrication is supplied and control is by a hydraulic governor. The engine, here seen on the test bed, has a continuous rating of 3500 b.h.p. at 375 r.p.m., and will be installed in a dredger being built for the Westminster Dredging Company, Ltd., for driving a pump.



A Mark KV.SS16 engine, rated at 4128 b.h.p. at 428 b.h.p. on the test bed



A Mark JVS.12.T rail traction unit developing 1250 b.h.p. at 850 r.p.m.

Smoke Control Areas

ORDERS for the creation of smoke control under the Clean Air Act of 1956 have been confirmed for Bolton and Denton in Lancashire; Hayes and Harlington in Middlesex; Osset in Yorkshire, and West Bromwich in Staffordshire. These orders cover a total area of some 380 acres and include 920 buildings. They come into operation during 1958, and with the exception of West Bromwich no objections to any of the orders were received. The only other order which has been confirmed under the Act dealt with the city centre of Liverpool.

The objections received in the case of the order in connection with the town centre of West Bromwich were from householders and were heard at a public inquiry. The principal objections were that the smoke nuisance from industries and railways should be reduced before householders were required to burn smokeless fuel, and that coke fumes in houses suffering from downdraught were dangerous to health. In announcing the decision to confirm the order, the Minister of Housing and Local Government stated that domestic chimneys were as much a contributory cause of smoke pollution as industrial chimneys. Dark smoke emitted from industrial establishments and the railway would be reduced when the Clean Air Act came into operation. He further stated that there was no question of coke fumes being more harmful than those from coal—they were virtually the same.

B.B.C. Band V Experimental Television Transmissions

THE B.B.C. recently started a series of high-power test transmissions on 654·25 Mc/s to collect further information about the u.h.f. bands (bands IV and V), which were allocated to television at the International Radio Conference at Atlantic City, 1947, but have not so far been used for television broadcasting in this country. It may be recalled that the v.h.f. and u.h.f. bands allocated to sound and television broadcasting are as tabulated here :

Band I, 41–68 Mc/s, v.h.f. ...	Used for B.B.C. television
Band II, 87·5–100 Mc/s, v.h.f.	Part used for B.B.C. sound programmes
Band III, 174–216 Mc/s, v.h.f.	Part used for I.T.A. television
Band IV, 470–585 Mc/s, u.h.f. } Band V, 610–960 Mc/s, u.h.f.... }	Not yet used for television broadcasting in Great Britain

After earlier laboratory work, the B.B.C. began its first series of u.h.f. propagation measurements in 1955. These tests were directed towards the investigation of propagation on frequencies between 470 and 960 Mc/s over distances representing a normal service area, and over longer distances to obtain data necessary for the evaluation of co-channel interference. The initial tests were for the latter purpose and employed transmitters, modulated by square waves, manufactured for the B.B.C. by Mullard, Ltd. The transmitters were installed at various television transmitting stations, the aerials being erected high up on the television masts. Regular field-strength measurements were made over long periods at various locations, some as far away as the Shetland Islands. These transmissions are still in progress.

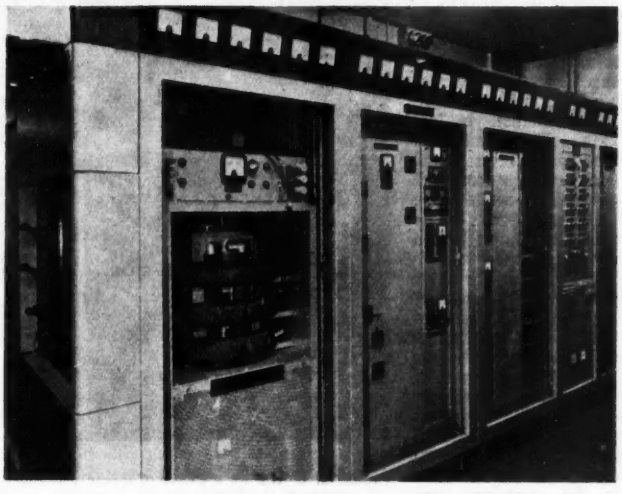


Fig. 1—2·5kW band V sound transmitter, showing klystron output stage in foreground

In 1956, the long-distance tests were followed by a series of tests to determine propagation conditions within a typical service area using a transmitter at the Crystal Palace on 495 Mc/s, working into a Yagi aerial and radiating a peak power of 1kW over a fairly narrow beam when modulated with square waves ; pulse modulation was also used for some of the tests. The bearing of the aerial, which was at a height of 440ft, was changed from time to time so that field strengths could be measured over the whole circle from Crystal Palace. These measurements have been completed and the resulting information concerning field-strength contours and an assessment of shadow and echo effects are now being studied.

However, the information collected in this way was insufficient to determine fully the best way of using bands IV and V for television broadcasting, and at the request of the Television Advisory Committee the B.B.C. decided earlier this year to embark on a more ambitious series of experiments using a high-power transmitter and radiating full television signals, initially on 405 lines and later on 625 lines (C.C.I.R. standards). These tests have been planned by the B.B.C. in co-operation with the Television Advisory Committee and the radio industry.

For this purpose the B.B.C. has installed at the Crystal Palace a 10kW peak-white u.h.f. vision transmitter and a 2½kW carrier power sound transmitter (Fig. 2), manufactured by E.M.I. Electronics, Ltd. The vision frequency is 654·25 Mc/s, but we learn from the manufacturer that the transmitter is available for operation at any frequency in the range 470 to 960 Mc/s. The equipment is low-power modulated on both sound and vision channels and employs "Eimac 3K50000LF" klystrons in both audio and video final stages. These klystrons use three external cavity resonators and operate as linear amplifiers with a power gain of approximately 100. They are driven by a modulated amplifier stage operating with a cathode-modulated circuit. The cathode is held at −17kV, the remainder of the circuit being at earth potential. The three external cavity resonators are separated by water-cooled drift tubes. In this particular installation the sound and vision transmitters are installed side by side in a single bay (Fig. 1). In the centre is a control panel with push-button controls and mimic diagrams for the sound and vision transmitters. On the left of this central panel is the sound transmitter and on the right the vision transmitter. On the extreme left (Fig. 1, foreground) is the klystron cubicle of the sound transmitter, and the focussing coils can be seen.

The output of the transmitters is combined in a circuit of the filter bridge type constructed in rectangular section waveguide. The combined output is then conveyed to the aerial by an elliptical waveguide, made of 99·5 per cent aluminium in 12ft lengths (Fig. 3). The elliptical cross section has major and minor axes of 12in and 6in, respectively, and the tolerance on the internal dimensions is ±0·04in. At the top of the television mast the waveguide is transformed into a 5in concentric feeder to take power to the four driving points of the helical aerial, the pole supporting the aerial being arranged to form the outer of the concentric feeder.

The helical aerial is made of ½in diameter copper rod and comprises four bays mounted one above the other on the same vertical axis, each having a linear height of five wavelengths. Each bay is fed at the centre (Fig. 2), the helix being wound from the centre point of the bay in opposing directions to cancel the vertical component of radiation. In the four bays there is a total of forty-eight turns, each turn being approximately two wavelengths long. The aerial is mounted at the summit of the Crystal Palace tower, the top of the 6½in diameter pole supporting the aerial being 707ft above the ground, while the centre line of the aerial is 691ft above the ground. The aerial has a power gain of 20, and after allowing for losses in the feeder and waveguide system, the effective radiated power of the vision signal is of the order of 125kW peak-white in the horizontal plane. Provision is made for de-icing the aerial by electrical heating.

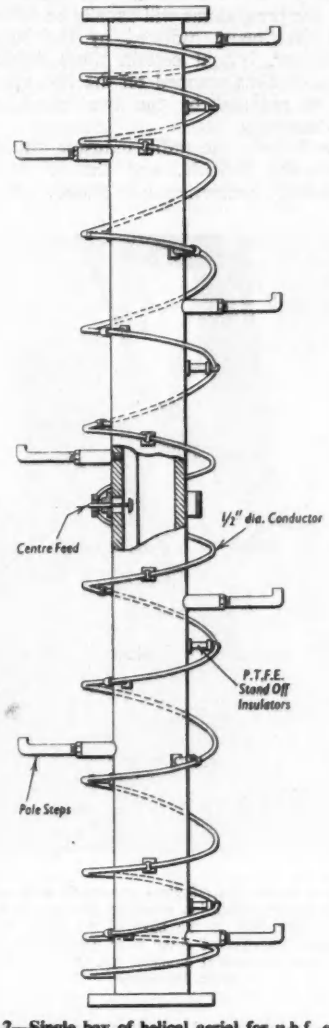


Fig. 2—Single bay of helical aerial for u.h.f. experimental television transmissions. There are four such bays at the top of the B.B.C. Crystal Palace tower

At Crystal Palace, the band V transmitter is in operation for several hours a day radiating pictures on the 405-line standard. The pictures are the same as those radiated by the band I transmitter installed in the same building. Later on, pictures on 625 lines will be produced at Lime Grove from flying spot teleciné equipment supplied by Cinema-Television, Ltd., and will be sent over a specially equipped coaxial cable to the Crystal Palace.

The tests on 405 lines will continue until about March, 1958, when there will be an interval for the transmitter to be adjusted to radiate on 625 lines. A second series of tests will then begin and will continue for a

period yet to be decided. For these latter tests, the programme will usually be different from that being radiated by the band I transmitter, but at certain times duplicate copies of films scanned on the two systems will be radiated by the two transmitters simultaneously.

The B.B.C., the radio industry, the Post Office, the D.S.I.R. and the I.T.A. are organising comprehensive studies of the

Fig. 3—12in by 6in elliptical waveguide with angles and concertina expansion couplings running from the aerial feeder duct to the base of the aerial tower. The partly constructed cover is to protect the waveguide from mechanical damage, e.g. from ice falling from the tower

received pictures. A number of experimental receivers of various kinds will be used, some being representative of the designs that might be expected to become available to the public in the future. The B.B.C. hopes that the information which will be gained from these tests will throw light on the problems to be considered by the Television Advisory Committee when preparing its recommendations for the future development of television in the United Kingdom, in particular on the problems which would be encountered were it decided to provide television service in the u.h.f. bands, and on the effects of a possible change of United Kingdom television standards for these bands to conform with the standards used on the Continent. There is, of course, no intention of making any change in the 405-line standards used in bands I and III.

Self-Regulating Alternators With Class-E Insulation

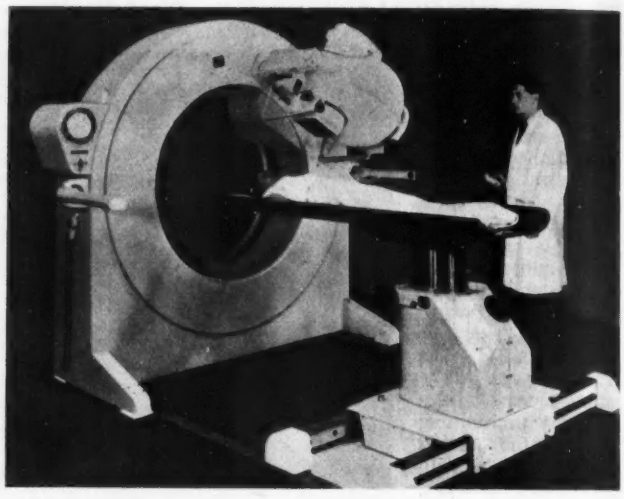
A NEW range of self-regulating "Magnicon" alternators, with ratings from 3kVA to 50kVA has been announced by The Macfarlane Engineering Company, Ltd., Glasgow. In this "RS" range of machines a reduction in size has been effected by taking advantage of the higher temperature rises specified in B.S. 2613 : 1957 for class-E insulation, and by adopting a rotating armature design with an improved field system. Because of economies in materials, the "RS" "Magnicon" alternators are sold at prices lower than those of the company's "C" and "L" machines.

The "RS" alternators have direct-coupled exciters, the exciter armatures being hub-mounted on a tapered extension of the main alternator shaft. Normally the machines are supplied with the items of control gear loose, for fitting to the user's switchboard, and cable tails up to 4ft in length are brought out from the machine frame. A casing can, however, be provided on the alternator to house the control gear and a terminal board.

Cobalt Therapy

COBALT-60 emits radiation similar to that from radium or an X-ray tube working at 3,000,000V. One "source" of radioactive cobalt can be used to treat patients in hospital for about five years. We are informed that the first Newton Victor "Orbitron," which employs cobalt-60 as a source, is now installed in the Radiotherapy Centre at Whitchurch hospital, Cardiff, where it will soon be undergoing tests. A second unit is to be shown this month at the Congress of the British Institute of Radiology and is destined for installation in an Italian hospital. The equipment consists essentially of a protective container to house the cobalt and confine the radiation to one beam, an annulus to which the container is attached so that it can be rotated about the patient, and a treatment table.

The protective container is in the form of two merged spheres of 23in and 14in diameter respectively. Sufficient space is provided to house a cylindrical source up to 2cm diameter by 3cm long. The source is secured in a recess at the periphery of a protective disc which rotates in a plane at 90 deg. to the axis of the beam. When not in use, the source is at the centre of the larger sphere in the "protected" position. For treatment the disc is rotated through 180 deg., bringing the source to the centre of the smaller sphere and opposite the radiation port in the "treatment" position. When a total of 2000 curies is housed in the container, and the source is in the "protected" position, the material surrounding the source is sufficient to reduce the radiation to less than $6{\cdot}25\times10^{-3}$r/hour at a distance of 5cm from the outer surface of the sphere. In the "treatment" position the protective material is sufficient to reduce the radiation to 2×10^{-3}r/second ($7{\cdot}2$r/hour) at a distance of 5cm from the outer surface of the smaller sphere or beam diaphragm.



Cobalt-60 is used as a source of therapeutic radiation in this hospital equipment. The operator is positioning the protective container in which the radioactive source is housed

The source is driven by a motor from the "protected" to the "treatment" position in a period of two seconds through an arc on the support side of the container and on completion of the treatment it is returned to the "protected" position by springs. The motor is energised during treatment and holds the source (against stops) in the "treatment" position. Failure of the motor or the electrical supply frees the source so that the springs return it to the "protected" position. As a further safeguard, the source can be returned to the "protected" position manually without removing parts or disengaging gears. A luminous indicator on the container shows the position of the source even in the absence of electrical supply.

The beam diaphragm fitted on the container has been dimensioned to permit rotational therapy at a source-to-axis distance of 75cm. The heavy metal blocks defining the beam are partially housed within the smaller sphere of the container and the whole assembly is less than 35cm from the source. The tungsten alloy beam diaphragms are constructed to move in arcs centred at the source of radiation so that the faces of the diaphragms are always parallel with the sides of the beam. Each pair of diaphragms is coupled together and adjusted by one knob. All square fields between 2cm and 21cm and all rectangular fields with diagonals not exceeding 30cm can be employed. The entire beam diaphragm system can be rotated on the beam centre line for stationary field work. With the source in the "protected" position, the field can be illuminated by a light housed inside the container.

The supporting stand is an annulus rotating in a yoke, thus avoiding the bearing loads and friction of cantilever structures. As the container housing the radioactive source can be rotated about the patient, the size of room and the cost of protecting the walls is reduced. The protective container mounted on the annulus rotates about an axis at a radius adjustable between 65cm and 75cm. The annulus is driven at a stabilised speed variable between $\frac{1}{4}$ r.p.m. and $\frac{1}{2}$ r.p.m., while an extra speed of 1 r.p.m. is available for setting up purposes.

The container is mounted in a fork with the source 19in from the front face of the annulus. Manually operated gear tilts the container from 30 deg. towards the annulus through vertical up to horizontal making a total of 120 deg. Motor-driven movement of the fork provides a radial movement of the container from 65cm to 75cm simultaneously moving counterbalancing weights so that the complete annulus and container assembly is always in dynamic balance. Softly sprung bumper bars project from the container to stop the rotational movement of the container and return the source to the "protected" position should the patient move into, or the treatment table obstruct, the path of the container.

The treatment table moves freely on rails, both parallel with and normal to the annulus. Handwheels, operating through gears engaged only when the handwheel is turned, provide slow-motion drives in both directions for final adjustment. As every patient is raised to approximately the height of the axis of rotation the table top is moved vertically by a motor-driven hydraulic mechanism.

The control can be accommodated on a shelf, writing desk or table in the control room.

Steel-Making Equipment

WE are informed that Head Wrightson Iron and Steel Works Engineering, Ltd., is able, as a result of its association with the German firm of Bamag, to offer designs and complete engineering services for the "Kaldo" process of steel production in Great Britain.

Early experiments were carried out by Professor Bo Kalling, using a small 3-ton capacity rotary experimental furnace, pure oxygen being blown on to the surface of the metal through a lance

located at one end of the cylindrical furnace. Experiments at the Domnarvet (Sweden) works of the Stora Kopparbergs-Bergslags A/B were continued until sufficient information was available to enable the development of a large unit for production purposes. This unit, with a capacity of 30 tons, has now been in operation at the Domnarvet Steel Works since May, 1956, Design and construction of the installation were by Bamag. The vessel is cylindrical, with a symmetrical nose, and can be tilted in the usual way within normal converter stands. In addition it can be rotated about its axis of symmetry at infinitely variable speeds from 0 to 30 r.p.m. A water-cooled oxygen lance is introduced through the nose of the vessel, which also serves as an outlet for the exhaust gases. Blowing is carried out with the vessel tilted to an angle of 18 deg. to the horizontal, axial rotation of the vessel producing the necessary stirring action of the bath. Ore additions are used for cooling purposes, measured quantities being charged from high level bunkers above the vessel. Bunkers for lime additions are also located above the vessel.

The percentage rate of phosphorus oxidation is greater than that of carbon, with the result that it is possible to "catch" the carbon at any reasonable level. Further, the nitrogen content in the finished steel is said to be exceptionally low, 0·002 to 0·003 per cent on rimmed steel with oxygen only 95/97 per cent pure. The majority of steels produced at Domnarvet fall into the low-carbon group. The following table illustrates two typical heats and, in each case, the phosphorus content at 0·8 per cent carbon is indicated :—

		C	Si	P	S	Mn	N
1	Hot metal	3·82	0·75	0·081	0·059	0·76	—
		0·80		0·015			
	Steel	0·15	—	0·015	0·028	0·67	0·002
2	Hot metal	3·52	0·09	1·70	0·056	0·41	0·007
		0·80		0·04			
	Steel	0·10	—	0·028	0·014	0·66	0·002

On average, the ore and lime additions each represent about 14 per cent of the hot metal charged. Scrap may be used in place of ore but, as its cooling effect is very much less (about one-third of that of ore) correspondingly greater quantities must be used.

Certain features of the Domnarvet installation were dictated by the need to utilise existing converter stands within an established building. Nevertheless, experience has been gained by the installation and operation of this unit, and designs are now completed for the manufacture of Kaldo vessels of up to 100 tons capacity. Three such vessels would constitute a plant capable of a steel output of 1,000,000 ingot tons per annum.

In preparing new designs, attention has been paid to the fume disposal. Although the volume of dust is much less than that from oxy-blown Bessemer converters, the present-day emphasis on smoke abatement, coupled with the desirability of recovering iron from the dust (about 0·5 per cent of the iron charged), calls for some means of rough gas cleaning. A water cooled hood has been arranged to swing over the neck of the Kaldo vessel, when the vessel is tilted ready for blowing. This hood supports the oxygen lance and ensures the correct operating position of the lance. The very hot waste gases leaving the converter mouth are diluted with induced air, and then pass through the hood and water cooled flue to a dust catcher and stack.

Synthetic Flexible and Rigid Foams

A NEW plant, built specially for making organic isocyanates, has been brought into production at the Huddersfield factory of I.C.I. Dyestuffs Division. These isocyanates are sold under the trade name "Suprasec," and four new brands, "Suprasecs" SF, D, AC and F, supplement and, to some extent also, replace the established "Suprasecs" C and DX. The "Suprasec" curing agents are used in conjunction with various polymeric reactants to produce, according to the particular isocyanate and reactant selected and the proportions and conditions employed, flexible foams, rigid foams, soft and hard rubbers, lacquers, textile coatings, electrical insulating compositons, and adhesives.

"Suprasec" SF (tolylene diisocyanate) is used in conjunction with "Daltocel" SF, a polyester compound, to produce "polyurethane" flexible foams that can readily be cut into sheets or shaped and bonded. The foams possess good load-bearing capacity, great durability, are easy to work, and are virtually non-inflammable.

Rigid foams of great lightness and strength, used mainly for thermal insulation, are produced from "Suprasec" D and "Daltolac" 21, and have the same chemical and physical characteristics as the flexible foams. They can be made on the spot where they are required, obviating the need for transporting bulky preformed blocks, and can be formed *in situ*, even in awkwardly shaped or barely accessible cavities, and should find valuable use where their firm adherence to the metal or other surface makes them an integral part of the assembly. In building, their applications include partitions for thermal and sound insulation, lightweight walls and ceilings, anti-condensation coatings, and use as plaster substitute.

Soft rubbers are obtained by reacting isocyanates with certain polyesters, and such rubbers are being used for printers' rollers, because of their inking properties and ease of cleaning, printers' blankets and soft sealing compounds.

Polyurethane surface coatings produced from "Daltolacs" 9, 10 and 11, used in conjunction with "Suprasecs" AC, C, DX and F, offer high resistance to solvents, oils, chemicals and ageing.

High flexibility is an inherent characteristic of the polymer films produced and does not depend on added plasticisers. Metals such as aluminium and its alloys, often difficult to coat satisfactorily, normally give no trouble with "Daltolac"/"Suprasec" lacquers.

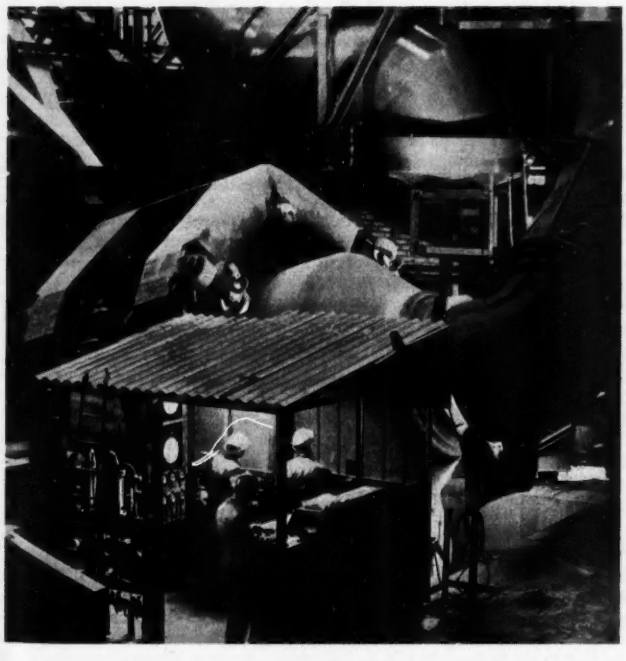
The "Daltolac"/"Suprasec" compounds represent an advance on earlier textile coating compositions in that they adhere firmly to the newer synthetic fibres, and "Daltolac" 11 has been developed for use, with "Suprasec" C, in electrical insulating coatings. "Potting" compounds which have good electrical insulating properties and are suitable for supporting and immobilising delicate electronic devices in guided missiles, are made from "Suprasec" isocyanates and castor oil.

Bulk Cement Batching Equipment

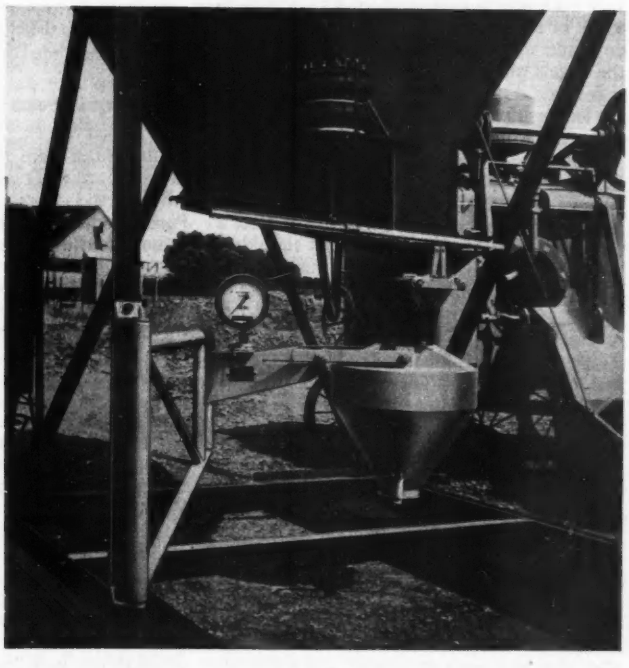
To facilitate and speed the handling of bulk cement to concrete mixers on constructional sites, Blaw Knox, Ltd., of 94, Brompton Road, London, S.W.3, has introduced a new "Supersilo" bulk handling equipment. In this equipment a rigid frame structure supports an 8ft square cement storage bin which can be of 20 or 30 tons capacity. Fitted in the base of the bin is a low pressure air slide actuated by an automatic aerator which ensures a quick and clean discharge and cut-off.

A weigh hopper, which can be seen in the accompanying illustration, is pivotally mounted on a bracket on the main structural column. This hopper has a 5ft 6in maximum radius of swing and the standard discharge height below its base is 17in. Its support arms incorporate a weighing system with a large indicating dial calibrated in 5 lb divisions up to 300 lb. In the batching cycle, when the hopper has been loaded with the required weight of cement, it is swung sideways for its contents to be deposited into the skip of a cement mixer at the side of the equipment.

If required, two weigh hoppers can be fitted, one on each side of the main structure, to operate in conjunction with two concrete mixers, each of up to ½ cubic yard capacity. An alternative weigh hopper available has a capacity of 600 lb.



A Kaldo vessel at the Domnarvet works in Sweden, with a capacity of 30 tons



Weigh hopper in loading position beneath cement storage bin feed slide

Industrial and Labour Notes

Overseas Trade

In its survey of Britain's overseas trade during October, the Board of Trade comments that " the rise in imports was much sharper than in exports, and the visible trade deficit, which had declined in the two previous months, widened to £70,000,000." The value of October exports of United Kingdom goods was £271,800,000, and although that was £25,000,000 above the September figure, the Board says that it indicates a recovery smaller than has generally occurred between these two months in past years. The October export figure was 1½ per cent below the average for the first nine months of this year.

The Board goes on to say that, for what is usually one of the best months of the year, October exports were rather disappointing ; the " shortfall " in the usual seasonal recovery was distributed over a large number of commodities and markets. But exports of road vehicles and of steel were higher in October than the average for the first nine months and thus maintained the large increases shown this year over 1956. There was also a recovery from the low level of the third quarter in exports of refined petroleum. In most other cases, however, shipments in October fell a little short of the January-September level. Exports of machinery, in particular, failed to maintain the strong underlying rate of growth which developed during the second and third quarters of the year, and exports of textiles and chemicals were also more subdued.

The value of imports in October was £353,100,000, which was 2½ per cent above the average for the first nine months of this year. The Board of Trade says, however, that the rise over September was very largely seasonal, the October figure maintaining the recent tendency for the value of imports " to show diminishing rate of increase compared with the corresponding period of 1956."

The Canadian Trade Mission

A Canadian Trade Mission to the United Kingdom has begun its programme this week and is now engaged on a round of visits in all parts of the country, which will continue until December 18. The mission, the largest which Canada has ever sent abroad, is composed of fifty-seven industrialists under the leadership of the Hon. Gordon Churchill, Canada's Minister of Trade and Commerce. The purpose is to stimulate British exports to Canada. This trade mission, it has been stated, is essentially a purchasing mission, although it is not expected that it will place a large number of orders ; the effect should be " long range rather than immediate." It has also been stated that most of the members of the mission are interested in the purchase of machinery of all kinds.

Speaking at a press conference in London, just after the members of the mission arrived last Friday, the Hon. Gordon Churchill said that with the active co-operation of British industry a larger share of the Canadian market might be obtained by United Kingdom exporters. That, he added, was the objective which the mission had in mind, and, consequently, its members would be placing particular emphasis on searching out new sources of supply in the United Kingdom for items which Canada was now buying from other countries. Since 1952, Mr. Churchill continued, overall output in the United Kingdom had risen at roughly the same rate as in the U.S.A. and Canada. The increase in production had been especially notable in the case of the export industries, where it had helped British producers to arrest the decline in their relative importance as suppliers of Canada's import requirements. With the inauguration of an improved trans-Atlantic telephone service and the speeding-up of air transport, Mr. Churchill observed, the United Kingdom was now in a position to offer more rapid delivery and provide the short-order servicing of equipment to which Canadian users were accustomed.

Industrial Films

Annacis Industrial Estate, situated in the Vancouver industrial area, some 20 miles from the American border, was officially opened on July 22, 1955. A new colour film entitled " Opportunity to Let," recording the progress made, has been produced by Grosvenor-Laing (B.C.), Ltd., and was shown recently in London. The 1200 acre estate is being developed exclusively for industry and is administered by the Grosvenor-Laing organisation of Great Britain. It provides for companies wishing to build their own plants and for those that prefer to rent land and buildings. The film shows in detail some of the factories already in operation on the estate, and describes the many different kinds of factories which are available. Attention is drawn to the facilities already available, which include fresh water deep sea docks or waterfront sites for companies requiring their own wharves, five main-line railroads, and an extensive concrete highway system. The film runs for twenty-eight minutes and is available in 16mm size.

A second film, also shown in London recently, has been produced by the Graviner Manufacturing Company, Ltd., and deals with explosion protection and suppression for industry. Many experiments carried out by the company, together with actual test explosions under controlled conditions, have been linked together in this film to illustrate clearly the effect of the company's equipment in use. The mechanism of an explosion is explained and typical pressure/time curves for vessels of various volumes are shown ; the working of an explosion detector is illustrated, and the method of suppression.

Industry in South Wales

Last week, two deputations from South Wales were received by the President of the Board of Trade, the Minister for Welsh Affairs, the Minister of Power, and the Parliamentary Secretaries to the Ministry of Labour and the Ministry of Transport. The first of these deputations consisted of representatives of the local authorities in West South Wales. It emphasised, in particular, the claims of the area for the siting of a new integrated steel plant. But as such a project would take several years to complete, the members of the deputation urged the need to retain and modernise the existing old steel plants and to introduce " industries ancillary to such plants such as section mills."

The second deputation represented the Welsh Board for Industry. It was led by Captain H. Leighton Davies, who submitted a comprehensive review of the situation developing in West South Wales as a result of the actual or impending closure of the old tinplate and sheet steel works. In particular, he stressed the need for an early decision on, first, the siting of the proposed integrated steel plant, and, secondly, the relief of the traffic " bottleneck " in the centre of Port Talbot. At the same time, Captain Leighton Davies emphasised the need to find new industry for the area.

The Ministers assured both deputations that they were " fully alive to the situation." It was not yet possible, they said, to state when a decision about the new steel works would be reached. With regard to the traffic problem at Port Talbot, however, " a decision was likely to be taken in the near future."

Economic Prospects

During his chairman's address at the annual meeting of Eastwoods, Ltd., last week, Sir Thomas Moore, Bt., commented on various aspects of the economic future, in the light of the Government's present policy. Externally, so far, he said, that policy had been successful as the pound had strengthened to parity with the dollar and German mark and a second devaluation of sterling, which was being freely canvassed only a month or so ago, was now regarded as remote, if not entirely unthinkable. But, Sir Thomas added, the business community and organised labour in Britain had now to face the fact that the annual dose of inflation which provided easy profits and automatic wage advances would no longer be forthcoming. This new situation would impose on everyone what, at first sight, might appear to be an unwelcome discipline, but it must be remembered that whatever profits or wage increases arose out of inflation, and not as a result of greater production, they gave only a temporary advantage to whatever group got in first.

In some more specific references to wages and kindred matters, Sir Thomas commented on a recent estimate that, if a forty-hour week were to be established throughout British industry it would add at least £1000 million to the national wage bill. It was not surprising, he said, the Chancellor of the Exchequer had been constrained to point out that if wage claims were granted on the scale still being demanded in certain quarters, the result would be economic disaster for all. It was to be hoped, Sir Thomas observed that the attitude of the trades unions would be profoundly modified as soon as the facts of the situation became more clearly understood and appreciated by them and the general public.

Gross Fixed Investment

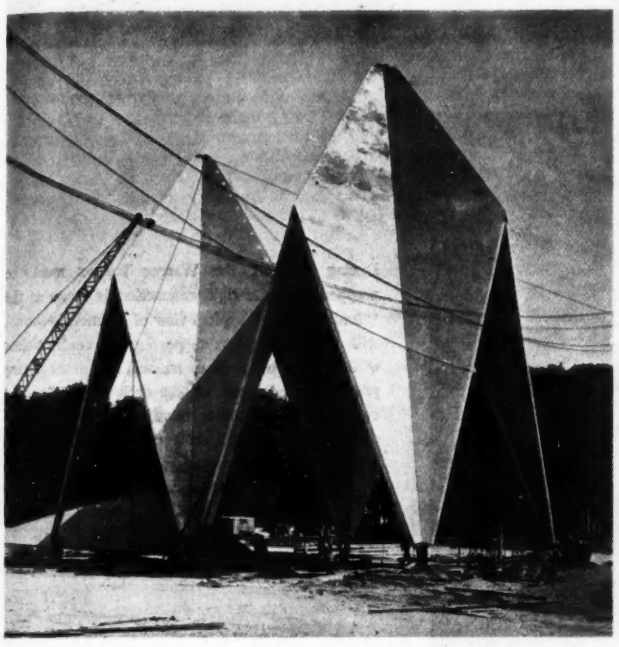
A note in *Bulletin for Industry*, which is prepared monthly by the Treasury, reviews the growth and make-up of investment in the last few years. It explains that, since 1953, the total of gross fixed investment has been rising fast ; there has been a shift away from social investment towards the more directly productive forms, and from the public towards the private sector of the economy.

The *Bulletin* points out, however, that although the volume of investment has been high and rising in recent years, the rate of increase has been falling—11 per cent in 1955, 7 per cent in 1956, and 5 per cent in the first half of 1957. Forecasts of capital expenditure by manufacturing industry, made early in the summer, suggested that there might be no change in 1958. In view of the increase in the Bank rate and other financial measures announced by the Government, a rise in the total of investment, now at a record level, is unlikely next year.

British Pavilions at Brussels

WE recently published a brief review* of the work now in progress at the site of the 1958 World Exhibition in Brussels, and of the principal structures which are being erected for that event. Some further details are given here of the structural design of the buildings in the British section of the exhibition. Two of the buildings—the crystalline hall and the British Industries pavilion—are noteworthy examples of a structural technique known as folded slab construction, which the consulting engineers have applied to a number of buildings over the past few years; in fact, the transport pavilion at the Festival of Britain—described in this journal at the time—was an early example of this technique.

The three-dimensional properties of the "shell" roof are well known; the folded slab idea is analogous, and a roof built on this principle will consist of a number of slabs, each inclined at an angle to the next. A shearing force will develop along the junction of two slabs and must be resisted, so that both slabs deflect equally at the junction. Applied forces can then be resolved into components parallel to the plane of each slab. Each slab is, of course, stiff in its own plane, and by the "folding" configuration and coupling the slabs together, stiffness perpendicular to any one slab is also achieved.



Erection of timber slabs of the Crystalline Hall. Vertical infilling panels will complete the structure as shown here. Note the pair of slabs awaiting erection

The crystalline hall is a good example to illustrate this form of construction. It is a timber building consisting of three pyramids, each 69ft high and 37ft square at the base. The accompanying illustration shows erection of the crystalline hall at a fairly early stage, with the main structural elements for two of the pyramids erected. The triangular spaces are now closed by vertical panels. Considering one pyramid, it can readily be seen that if four flat slabs had been erected to form it, each panel would have needed considerable stiffening to resist sagging. But by folding each panel in its centre this stiffening is effectively provided, by virtue of the principle just described. The vertical triangular panel can then be added to support the free edges of contiguous slabs, thus giving further rigidity. The "dihedral" between the two slabs carried on one of the steel supporting bearings is about 113 deg., and it has been possible to proportion each slab with a thickness of 6in. Substantial softwood timbers form a stiff grillage which has a ¼in plywood skin on each face, which acts structurally as a stressed skin giving stiffness in the plane of the slab. Erection was devised without falsework, and again pairs of slabs had to be erected together to avoid sagging. It was considered, however, that two slabs forming, on plan, the side of a pyramid, and not the two carried on one corner, should be erected together. The bases of each pair of "side" slabs were simply fitted to the 2in diameter pins, one at each corner, of the supports, and the top of the assembly raised into position. A rigid site joint was made between adjacent pairs of slabs.

The Hall of Technology

The British Government's pavilion is in two parts. Next to the crystalline hall is the hall of technology, which is roofed with a space frame, of the kind described in THE ENGINEER of July 6, 1956, page 6. Such a frame gives flexibility in column spacing, and can be dismantled and used again, which is a considerable advantage for a temporary exhibition building. The space frame consists of tubular steel and angle iron elements framed into tetrahedrons. The tetrahedrons are assembled with their bases uppermost, and tie rods are connected in a grillage across the apices and adjusted with turnbuckles to complete the frame.

The British Industries Pavilion

The British Industries Pavilion is again an ambitious example of the folded slab system of roof construction, and illustrates particularly well one of the principal virtues of this system of design. There may be economy in weight of steel or in cost with some of these roofs, or they may not show an appreciable saving, but they allow a more satisfactory architectural treatment than can be achieved with more conventional steelwork, such as roof trusses. The British Industries Pavilion is particularly clean in line, and has an open gracefulness due to its plate-glass walls as well as to the steelwork design. Whilst being very modern in concept, it has, paradoxically, something in common with the atmosphere of nineteenth century railway architecture in cast iron.

The pavilion is 90m by 60m in size and its height varies from 6·10m at the head of the columns to 10·67m at the centre and perimeter of the building. The roof construction consists of six bays, each 30 metres square, and with a column in the centre from which four arch ribs radiate, dividing the roof into segments. Each of these segments is roofed by six lattice girders, spanning as a folded slab construction between the diagonal ribs. The diagonal ribs and columns in adjoining bays act as three hinged frames and the horizontal members of the girders of each bay act as ring ties.

The welded lattice steel girders are made with 8in by 3in channels as chord members and 5in bore tubes as diagonal members. There are bolted connections between the girders, but the connections of the girders to the diagonal ribs are welded. The total weight of the lattice girders is approximately 202 tons. The diagonal ribs are 24in by 7½in I-section, with stiffening plates, and weigh 108 tons approximately. The columns are latticed steel members and weigh approximately 15 tons.

The architects for the British buildings in Brussels are Messrs. Howard V. Lobb and Partners for the British Government's pavilion, and Mr. E. Mills for the Federation of British Industries' pavilion; the display designers are respectively Mr. J. Gardner and Mr. J. Lansdell. The structural engineering consultants for both of these buildings are Messrs. F. J. Samuely and Partners.

The main contractor for both pavilions is R. Costain, Ltd., in association with Entreprises Blaton-Aubert. For the crystalline hall, the timber manufacturing and erection was done by the Rainham Timber Engineering Company, Ltd., and the erection consultants were T. W. H. Taylor and Sons. The space-frame roof of the hall of technology was the responsibility of Space Decks, Ltd. The steelwork contractor for the British Industries pavilion was Carter Horseley (Engineers), Ltd.

* THE ENGINEER, November 8, page 687.

Oil Tanker "Tidewater"

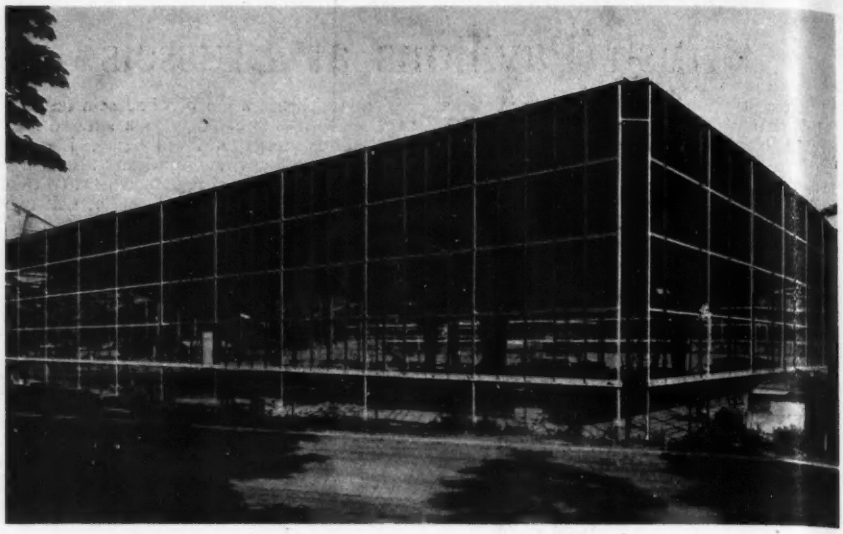
The third of the group of oil tankers of 51,850 tons deadweight ordered by the Tidewater Oil Associated from French shipbuilders was completed recently by the Chantiers de l'Atlantique Penhoët-Loire. The ship, named "Tidewater," has a length overall of 785ft 7½in, a length between perpendiculars of 747ft 11in, a breadth moulded of 102ft ½in, and a depth of 51ft 8in, while the maximum loaded draught is 38ft 6in and the full-load displacement 67,100 tons. Two longitudinal bulkheads and eleven transverse bulkheads divide the hull into thirty-six cargo oil compartments; the cargo is loaded and unloaded by four turbine-driven pumps, each having a capacity of 1130 cubic metres per hour. The derrick complement includes four to lift 5 tons, two of 3 tons capacity and two of 2 tons capacity, powered by three steam winches. Both the capstan and the windlass are steam driven, while the steering gear is of four-ram design fitted with two pumps driven by 70 h.p. electric motors. Accommodation is provided for a crew totalling sixty-four, and is air conditioned.

Propulsion is by a single set of C.E.M.-Parsons double reduction geared turbines developing 19,000 s.h.p. and sufficient to maintain a service speed of 16·5 knots with an hourly consumption of 238 gr./h.p./hr. (0·425 lb/h.p./hour). Steam for the main machinery is supplied at 600 lb per square inch and 850 deg. Fah. by two Foster-Wheeler Mariner water-tube boilers. Electric power for ship services and auxiliary machinery is provided by two 650kW, 450V turbine-driven generators and one 75kW, 450V generator driven by a six-cylinder Renault four-stroke diesel engine of 115 h.p. at 1200 r.p.m. The fourth ship of the group is completing at the yard of the Ateliers et Chantiers de France at Dunkirk.

Fresh Water from Waste Heat

A novel design of fresh water generation plant for use on board ships has been produced and tested by Atlas Maskinfabrik, Copenhagen. The principle is that of utilising directly the waste heat in the engine cooling water. Some of this cooling water (which carries away 15 to 17 per cent of the total heat input and discharges from the usual main propulsion diesel engine at about 150 deg. Fah.) is passed not through the main heat exchanger but through the exchanger of the fresh water generator, in which a temperature drop of about 20 deg. Fah. occurs. A 93 per cent vacuum is maintained on the sea water side of the exchanger by a mechanical pump. Under those conditions some of the sea water is evaporated. After passing through a separator in order to remove any entrained water, the vapour is condensed in a condenser cooled by sea water. As only a small proportion of the sea water fed to the system is evaporated, there is no formation of salt deposits on the heating surfaces. It is stated that such plants could produce up to 8 tons per day per 1000 i.h.p.; outputs of over 7 tons have actually been realised.

British Industrial Pavilion at Brussels



Although its construction is still in progress in this illustration, the British industrial pavilion already shows its clean lines and the atmosphere of lightness given by the almost uninterrupted expanse of plate glass forming the walls, and the "mushroom" construction of the roof. Steelwork for the last two of the six "mushrooms" is being erected in the background

During erection, the Warren trusses must be propped until the rigid connection is made at the "fold." Here a typical view of erection is shown, with temporary props supporting the centre points of the outermost pairs of trusses, and a temporary prop also under one of the arch ribs. The end conditions at the outer boundary of this type of construction need special consideration, and in this design some propping action is given by the vertical elements carrying the glazing

Roof steelwork: the roof can be considered as a linked series of Warren trusses, spanning between the arched ribs. The plane of each truss is at a different inclination to the horizontal, depending on its position on the arch rib, and the top chord of one truss is attached to the bottom chord of the next, as shown by the double members, to give the rigid connection at the fold as explained in the article. These top and bottom members of the Warren trusses also act as ring ties for each "mushroom" of four arch ribs

Work of the U.S. Atomic Energy Commission

BY OUR AMERICAN EDITOR

No. I

THE twenty-second bi-annual report to Congress of the U.S. Atomic Energy Commission (A.E.C.) covers the considerable progress made by private American industry during the first half of 1957 in the development of nuclear power. During this period, the Atomic Energy Commission's experimental and demonstration power reactor programmes also moved further toward creating a wide technological base for economic production of electricity from nuclear fuels. The first United States reactor designed exclusively to produce civilian electric power, which is considered to be a pilot plant for large commercial reactors, was dedicated by the Commission in February at Lemont, Illinois, and since that date has supplied up to 5MW of electricity to the Argonne National Laboratory. The early performance of this Experimental Boiling Water Reactor indicated that it probably could produce twice its design heat output. A second pilot plant reactor, the Sodium Reactor Experiment, achieved criticality in April and began experimental operation at Santa Susana, California. Its operation is expected later to feed 6·5MW into the grid of the Southern California Edison Company on an experimental basis. The U.S. Army Package Power Reactor achieved criticality and later began producing electricity at Fort Belvoir, Virginia. This reactor is expected also to help meet civilian needs for small and "portable" nuclear power plants.

An additional 59,800 kg of uranium 235 was designated by President Eisenhower during the January–June reporting period for use over a number of years in peaceful applications of atomic energy, bringing to 100,000 kg the total earmarked for these purposes. The uranium 235, to be sold or leased, will be divided equally between users in the United States and in other countries. The President's statement called attention to an earlier promise, made at the time of the first major designation of nuclear material, that more supplies would be made available for sale or lease as necessary for additional nuclear power projects. The President stated his gratification that the advance toward nuclear power and scientific and technical knowledge was proceeding at a pace which required providing additional supplies.

Raw Materials

The production of uranium ore and concentrates from all free world sources continued to increase during the first half of 1957. The construction of new ore processing facilities in the United States and in other countries will produce further increases. The United States reached the position where a ten-year uranium supply is in sight. Accordingly, the supply from sources under contracts and from estimated increased domestic production will provide for the military and civil power development programmes as projected for the next ten years, and for the United States international commitments. Domestic production of uranium ore and concentrates continued to increase during the reporting period. The United States was the free world's leading uranium producer and gave evidence of maintaining this position for some time to come, with a predicted rate of production in excess of 10,800 tons of uranium oxide per year by the end of 1957. By the end of 1958 the annual production rate should approximate 14,000 tons of uranium oxide.

The main effort in the programme of raw materials process development during the first half of 1957 was in operation at the Grand Junction pilot plant in Colorado and the Winchester laboratory in Massachusetts. Additional studies were conducted by the Columbia University School of Mines; the U.S. Bureau of Mines Experimental Station in Salt Lake City; the Mackay School of Mines of the University of Nevada; the Dow Chemical research laboratory in Pittsburgh, California, and the Oak Ridge National Laboratory. During this period, tests were made at the Grand Junction pilot plant to demonstrate the amenability of particular ores to conventional processing and to derive the data necessary for contract negotiation. The ores under study were from the Ambrosia Lake area in New Mexico, from Wyoming, and from southern Oregon. It appeared that either acid or alkaline leaching might be considered for most Ambrosia Lake ores, subject to pilot plant tests when samples are available from additional underground workings. If acid leaching is used, solvent extraction for recovering dissolved values may be attractive as an alternate to ion-exchange resins. The acid-leach, solvent-extraction process is applicable to ore from southern Oregon. Another item in the pilot plant programme was work to develop a process suitable for the recovery of uranium from uraniferous lignite. Earlier laboratory work showed that this material should be amenable to a process including roasting to destroy organic matter, followed by conventional acid leaching and solvent extraction. Solvent extraction is considered superior to ion exchange for the recovery of dissolved values, because the impurities cause less interference in this process. The pilot plant demonstration checked bench-scale results on selected ore samples taken from major deposits in North and South Dakota. The economics of lignite processing pose a number of problems because the process includes roasting and high acid consumption.

The Winchester laboratory, which makes the preliminary study necessary to pilot plant demonstration, continued its investigation of new ideas for reducing costs and improving efficiency in uranium ore processing. A study of the characteristics of new solvents offered by chemical manufacturers and an evaluation of solvent extraction relative to resin ion-exchange as applied to the recovery processes of various established processing mills, were among important projects. At the Columbia University School of Mines work on methods for the recovery of uranium from Chattanooga Shale was being completed. This project was undertaken to develop preliminary process and cost data on the utilisation of this enormous potential of uranium. Two methods have been under study. One method involves the chlorination of the whole mass of shale and volatisation of the chlorides of uranium, iron, aluminium, potassium and some other metals. Subsequent process steps would re-claim chlorine for re-use and would recover valuable by-products, as well as uranium. This phase of the work was substantially completed. It indicated a possible method for future consideration. The other method concerned acid leaching by conventional, but specially adapted, procedures, followed by the recovery of dissolved uranium values by solvent extraction.

Solvent extraction, as a method for selectively recovering uranium from leaching liquors, is a relatively new process in extractive metallurgy. The leaching liquors from some ores may be more economically treated by solvent extraction than by ion exchange, and it appears that this process will be of value as an alternative. The use of solvent extraction in the recovery of uranium from ores is an outgrowth of the use of solvents in feed materials plants. The original work on development of suitable solvents for use in uranium ore processing was done by Oak Ridge and by Dow Chemical. The Development of processing techniques and their application have been studied by the Bureau of Mines at Salt Lake City, the Winchester laboratory, and the Grand Junction pilot plant. As a result of this research work, three privately-owned ore processing mills have adopted solvent extraction as more efficient than previous methods.

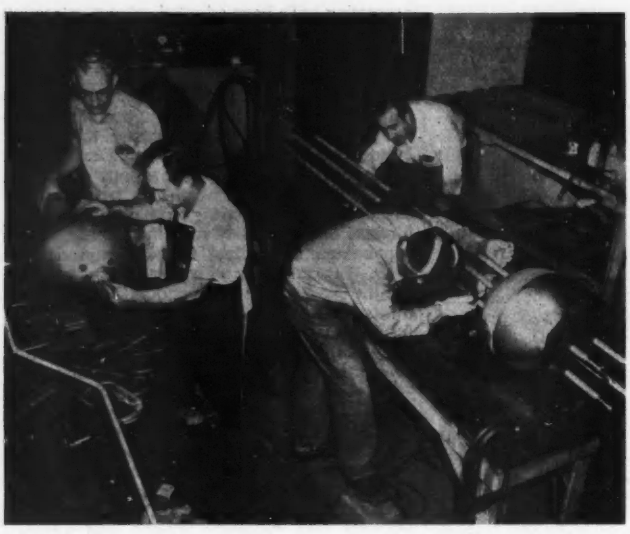
Military Applications

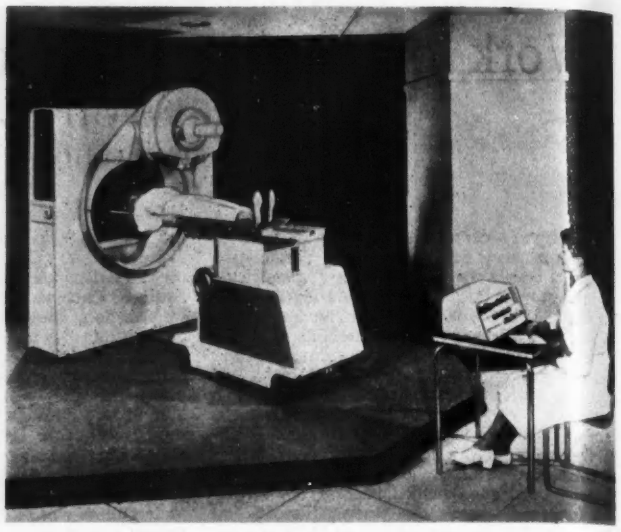
During the period of this report emphasis continued on research and development activities designed to improve and increase the United States arsenal of nuclear weapons. Development programmes continued on weapons employing new design principles which can be used more effectively for defensive purposes. Work went forward on methods of reducing the radioactive contamination resulting from weapon detonations. In accordance with Commission policy to use the Nevada test site periodically for experiments or tests involving nuclear detonations of relatively low yield, the Commission announced "Operation Plumbbob," the test series being conducted at the Nevada Test Site during this year. The operation began in March and continued through the summer. The objectives of Operation Plumbbob included development and exploratory tests which lead to the development of weapons for defence against attack; proof tests of weapons scheduled for production; development of more efficient weapons; development of weapons with minimum fall-out, and weapons effects tests in which the Department of Defence and the Federal Civil Defence Administration participated. In addition to the series of nuclear tests, there will be further experiments related to assuring the safety of various weapons and experimental devices in event of accident or fire during handling or storage. As in the past series at the Nevada test site, the Nevada Test Organisation was jointly staffed by the Commission, the Department of Defence, the Federal Civil Defence Administration and by their laboratories and contractors.

International Activities

The growing programme of international co-operation, under the President's Atoms for Peace programme, was focused during the reporting period on activities pursuant to the agreements for co-operation in atomic energy development with other nations, and on activities related to the establishment of an International Atomic Energy Agency. Assistance was offered in connection with the establishment of the European Community for Atomic Energy (Euratom). Emphasis was placed on developing the programme for interchange of technical information between the United States and other nations. Close liaison was maintained with the Department of State and other Government agencies in these activities. Increasingly, since the beginning of the programme for international co-operation, other nations have shown an interest in developing specific atomic energy projects. Discussions have been held with forty-nine nations and to date negotiations have been concluded on fifty agreements for co-operation. Four new agreements for co-operation went into effect—with Australia, Guatemala, Norway and Switzerland—making a total of thirty-six in force, of which seven included power reactors. In addition, negotiations were completed on fourteen agreements (six included power), and discussions were held on six other agreements, all of which would cover power. As of June, two reactors manufactured in the United States were operating in other countries, licences to export eight other reactors from the United States had been issued, and seventeen more were planned, including eight power reactors—a total of twenty-seven reactors installed or projected.

Two symposia on peaceful uses of atomic energy were held for representatives from the American states with the assistance of the Commission. At a regional conference in Puerto Rico, attended by 1200 persons, the Spanish-language nuclear centre to be established at the University of Puerto Rico with the co-operation of the Commission was described. Leading scientists, engineers and Government officials from the American nations attended a symposium at the Commission's Brookhaven National Laboratory which explored the present and future of nuclear technology and peaceful applications in the Americas. With the current enrolment of forty-eight students from twenty-five countries in special courses in atomic energy technology conducted for the Commission, 211





(Left) Fabrication by Atomics International in California of cores for two research reactors to be installed respectively at Frankfurt University and the Institute of Nuclear Research in West Berlin. (Right) Teletherapy unit employing cobalt 60 isotopes developed by the Westinghouse Electric Corporation for installation at the Oak Ridge Institute of Nuclear Studies

students from forty-one nations had received instruction. Five additional technical libraries were approved during this reporting period for presentation by the United States, raising to fifty-two the total to be placed in other countries or with international organisations. Emphasis continued on programmes for interchange of technical information between the United States and other nations, including planned participation in two major international conferences. The Commission also determined that it would give financial support to selected unclassified international conferences on scientific subjects relating to atomic energy.

During May the Advisory Committee to the Secretary General of the United Nations met in Geneva, to discuss plans for the 1958 International Conference on the Peaceful Uses of Atomic Energy. The United States was represented by Dr. I. I. Rabi, to whom the Commission supplied staff assistance. The Secretary General of the United Nations determined that the 1958 scientific conference would be held in Geneva in September, 1958. A detailed agenda, wide in scope, with emphasis on atomic power, was agreed upon and submitted to the Secretary General as a call for papers to be presented at the Conference. Within the Commission, an office for the International Conference was established to direct and co-ordinate the planning and organisation of the United States presentation, including an exhibit.

Radioactive Isotopes

During the past six months, several new industrial uses of isotopes were reported. One was the development of a tiny experimental atomic battery to power a wrist watch. The battery, which uses the isotope promethium 147, is about $\frac{1}{2}$in in diameter, has a useful life of more than five years and an output of 20 microwatts. Although not yet available for everyday use, larger future models of the battery are expected to power portable radios, hearing aids, and equipment in guided missiles and space craft. With this development five different types of atomic batteries have been announced. The batteries convert atomic radiation to electric current. Although the energy from the batteries is very small, they are useful for applications requiring tiny amounts of power. Their useful life depends upon the isotope used, but may be many years, and the batteries are virtually unaffected by temperature and humidity extremes.

In another potentially large-scale application the radiation from atomic energy by-products was successfully used for the first time in heatless vulcanisation of an automobile tyre without the addition of sulphur. The radiation-vulcanised tyre reportedly wears longer and resists deterioration better than tyres vulcanised by the heat method. This was the first basic change in the "curing" of rubber since the discovery of vulcanisation in 1839. In conventional vulcanisation, sulphur and other chemicals are added to rubber and it is heated to more than 300 deg. Fah. This treatment realigns the molecules to provide greater stability against temperature changes and deterioration. In this process, the carbon atoms are linked through sulphur atoms and this is considered a "weak link" in the vulcanisation of rubber. The radiation method resulted in a direct linkage of the carbon atomic chains in the rubber molecules.

A major industrial use of isotopes is in cigarette density gauging. The average density of tobacco in a cigarette is an important factor in cigarette quality and costs, since tobacco represents about 90 per cent of the production cost. A density gauge using strontium 90 as a source permits an automatic adjustment of tobacco feed and contributes to the uniformity of production. Isotope thickness gauges are used in automatically controlling mill rolls to reduce thickness deviations and consequent rejects in strip steel. The gauges can hold steel strip within 1 per cent of specified thickness. In the rubber industry, isotope gauges open and close calender rolls to control the amount of rubber coating placed on tyre cords, preventing over-use of rubber, improving utilisation of manpower, and reducing production time. Plastic and adhesive thickness gauges similarly improve usages in the plastics industry where raw material costs are usually high. Thickness gauges in the paper and allied products industries automatically control stuff gates to maintain accurate basic weight of paper produced and to help achieve faster machine start-up times after order change or break, and higher machine speeds, and also to reduce the number of rejects.

More than 500 organisations now use isotopes in radiographic testing. Used on a much larger scale than was previously economically feasible, radiography by means of isotopes is reported to cost only one-eighth to one-tenth as much as other methods. Reactor-produced cobalt 60, cæsium 137 and iridium 192 are now used in much the same way that radium formerly was used. Cobalt 60, equivalent in radiation intensity to 20,000 dollars' worth of radium, can be delivered for about 100 dollars, and its gamma rays will penetrate thicker sections of steel than will those from radium. Small isotope sources of high radiation intensity permit flexibility of operation as compared with fixed X-ray installations.

Reactor Development

In the first half of 1957, two power reactor plants in the Government's Experimental Reactor Programme were in operation. The Experimental Boiling Water Reactor (EBWR), which went critical late last year, began supplying 5MW of electricity for the Argonne National Laboratory. The Sodium Reactor Experiment (SRE) at Santa Susana, California, became critical in April and began initial low power tests. After these are completed, heat from experimental operations will be sold and will produce 6·5MW of electricity for the Southern California Edison Company. In addition, the U.S. Army Package Power Reactor began producing 1855kW of electricity at Fort Belvoir, Virginia. The Organic-Moderated Reactor Experiment (OMRE) at the National Reactor Testing Station and the Homogeneous Reactor Experiment (HRE–2) at the Oak Ridge National Laboratory were expected to become critical during the next reporting period. The first American full-scale atomic power plant, the Pressurised Water Reactor (PWR) at Shippingport, Pennsylvania, also was scheduled to achieve criticality this year. Under its Power Demonstration Reactor Programme, the Commission signed a second contract on a proposal made under terms of its first invitation for public and private groups to undertake building various kinds of power reactors. The Commission also received two responses to its third invitation, issued January 7, proposing power stations in Florida and the Mid-west. Under this programme, if the Commission accepts a proposal and negotiates a contract, it may support or undertake research and development required for the project, and may permit the use of special nuclear material at no charge. All technical and economic data developed are made available to the Commission for dissemination to the public. The third invitation, in generally broadening the scope of the programme, suggested specific types of reactors for which proposals were especially sought.

A contract covering research and development and preliminary design to demonstrate for the Commission the feasibility of a sodium-cooled, heavy-water-moderated reactor system was entered into. With two full-scale atomic power plants and one smaller one under construction by private organisations, three additional industrial groups announced during 1957 their plans to build four nuclear reactors for commercial purposes, bringing to ten the total announced as independent projects by industrial organisations in the United States. The Commission also signed a contract for designing and constructing the nuclear propulsion plant of the first nuclear-powered merchant ship.

Considerable progress was made in military reactor development. The reactor of the U.S.S. "Nautilus" was refuelled after having driven the submarine more than 62,000 nautical miles without refuelling. The U.S.S. "Seawolf" was accepted for restricted service, but the Navy Board of Inspection and Survey recommended replacing her sodium plant with a pressurised water reactor. The "SIG" land-based prototype

reactor for the "Seawolf" at West Milton, New York, was shut down. Work continued on land-based prototype power plants for two submarines and a large ship. Design and development work continued on nuclear propulsion plants for a cruiser and a destroyer. Progress continued in general engineering and development activities supporting both civil and military reactor programmes. The construction of the Commission's second large generalised test reactor, the Engineering Test Reactor, neared completion at the National Reactor Testing Station. Experimental plutonium fuel elements for the Materials Testing Reactor were fabricated and tested; subsequently, they were added to the reactor core and used as fuel elements. Further progress was also made in developing methods for safely disposing of radioactive wastes.

Fundamental to progress toward economic nuclear power, the Commission's Experimental Power Reactor Programme includes projects concerned with the development, design, construction and operation of the following reactors: pressurised water, boiling water, sodium-graphite, fast breeder, aqueous homogeneous, organic-moderated, liquid metal-fuelled, and molten plutonium. The concept underlying this multiplication of reactor experiments is that the present general low cost of electric power produced with the ample conventional fuels of this country affords the United States an opportunity, which it should exploit, to canvass all promising reactor designs so as to select those best suited to the various demands for nuclear power plants that will provide reliable, safe, and economic power for use in the United States and in other countries. With the exception of the Pressurised Water Reactor, the reactor projects in the experimental programmes are not full-scale power plants of a size which it is hoped to build ultimately for commercial production of nuclear power. Instead, they are reactor experiments undertaken on a scale large enough to provide definitive answers to technological questions. Ten such reactor experiments have been completed in the United States, four are under construction, and four more are planned.

Pressurised Water Reactor.—Installation of components continued in the Pressurised Water Reactor plant at Shippingport, Pennsylvania, designed by the Westinghouse Electric Corporation, as prime contractor to the Commission. The Duquesne Light Company, of Pittsburgh, Pennsylvania, is building the non-nuclear portion of the plant and will operate the entire plant when it is completed. The initial capacity of the station is expected to be in excess of 60MW. The reactor pressure vessel which will contain the fuel core was set in its final position, two of four coolant pumps were installed, and the main generator was placed in position on the turbo-generator side of the plant. Tubing of the main condenser was completed. Auxiliary equipment, switchgear and busses have been energised. The construction of the reactor service building was essentially complete. During this reporting period, re-estimates showed that costs for the nuclear portion of the plant will be 55,000,000 dollars, as against 37,750,000 dollars previously estimated.

Experimental Boiling Water Reactor (EBWR).—The Experimental Boiling Water Reactor at the Argonne National Laboratory was dedicated on February 9, when it began its first extended full-power tests. The EBWR is the first United States civilian reactor designed exclusively for generation of electricity to go into service and supplies 5000kW of electricity to the Argonne Laboratory. It was designed as a pilot plant for larger commercial power reactors. The reactor was completed on schedule at a cost of 6,100,000 dollars, including all building and the initial core but not the research and development work. The performance of the EBWR indicated that it probably can produce satisfactorily twice the design reactor power of 20MW of heat. A further increase in power may be achieved principally by forced circulation of the coolant. Future operating plans call for substituting heavy water for the light water now used as the reactor's coolant and moderator.

Boiling Reactor Experiment (BORAX-IV).—Power excursion tests were started in January with the boiling water reactor, BORAX-IV, at the National Reactor Testing Station in a series of experiments by the Argonne National Laboratory designed to study reactors of this type further. Steady-state boiling tests at atmospheric pressure were carried out during February with power levels as high as 2·6MW. Oscillations in reactivity levels were evident at higher power, but the general evidence indicated that the reactor was much more stable than anticipated. BORAX-IV is a modification of the previous reactor, designated BORAX-III, accomplished by substituting aluminium-clad uranium oxide-thorium oxide fuel elements. It will be used to test the stability and safety of such fuels.

Sodium Reactor Experiment (SRE).—On April 25 the Sodium Reactor Experiment went critical. During the initial start-up the reactor was operated at a power level of about 1kW of heat. No electricity was generated. The design capacity of the SRE is 20MW of heat. It was built by Atomics International, a division of North American Aviation, Incorporated, at Santa Susana, California. Numerous tests were begun to determine the nuclear characteristics of the reactor and to establish the satisfactory operation of all reactor components. After these tests, the power level of the reactor will be increased gradually. Heat will be purchased on an experimental basis by Southern California Edison to supply 6·5MW of electricity, from a generator installed by the company at no cost to the Government.

Fast Breeder Reactors.—A replacement core highly enriched with uranium 235—the third core for the Experimental Breeder Reactor No. 1 (EBR-1)—was under manufacture at the Argonne National Laboratory in order to put the reactor back into operation late in 1957. The second core of this reactor, which was damaged during a series of transient experiments in November, 1955, was removed from the reactor at the National Reactor Testing Station and shipped to the Argonne National Laboratory for detailed examination. The replacement core was designed to control inward-bowing of the fuel elements under certain conditions of coolant flow. Bowing is believed to have been a cause of the nuclear instabilities observed in operation of the reactor with the previous core. Mock-ups of several full-sized components for the Experimental Breeder Reactor No. 2 (EBR-2) and a one-quarter scale model reactor tank were operated at Argonne. These mock-ups included several large sodium pumps, fuel-handling equipment, shut-down cooling systems and fuel-reprocessing equipment. Such component and equipment tests have demonstrated the technical feasibility of remote handling mechanisms and other novel features of the EBR-2 design.

Miscellaneous Reactors.—The fabrication of the Los Alamos Molten Plutonium Reactor Experiment No. 1 (LAMPRE-1) continued at the Los Alamos Scientific Laboratory. The main effort was directed toward developing methods of fabricating tantalum, a material able to withstand corrosion from molten plutonium.

Pre-operational testing of the Homogeneous Reactor Experiment No. 2 at the Oak Ridge National Laboratory was resumed following a shut-down period in December that was caused by chloride-induced stress-corrosion cracking of stainless steel tubing in the leak-detector system. Non-nuclear tests with water and uranyl sulphate solutions at 280 deg. Cent. and 1700 lb per square inch were performed for more than 1200 hours during January, February and March. The results were satisfactory. Natural uranium was circulated at full design conditions for more than 500 hours. A complete inspection of the leak-detector tubing and the flanges to which the tubing is attached was made in April. Parts revealed by the inspection to have been damaged by the chloride contamination were being replaced. When the replacement is completed, final check-out runs will be undertaken and the reactor was expected to go critical late this year. The examination and evaluation of the Los Alamos Power Reactor Experiment No. 1 (LAPRE-1), which was abandoned in 1956, continued to assist in the development of Los Alamos Power Reactor Experiment No. 2 (LAPRE-2), which is expected to achieve criticality later this year. The main efforts on LAPRE-2, which in general is less complex than LAPRE-1, were on the development of a corrosion-resistant heat-exchanger. Leaks in the heat-exchanger were the cause of the shut-down of LAPRE-1.

The construction of the Organic-Moderated Reactor Experiment was completed by Atomics International at the National Reactor Testing Station and the reactor was scheduled for critical loading. The reactor, which will produce 5MW to 16MW of heat will demonstrate whether or not organic materials such as diphenyls or terphenyls may be used as coolants and moderators for a power reactor.

Research and development work on portions of the system for the Liquid Metal Fuel Reactor Experiment continued at Brookhaven National Laboratory under the contract with the Babcock and Wilcox Company, to develop, design and build a liquid metal-fuelled reactor. The work under way included an evaluation of graphite and other structural materials suitable for reactor fabrication, and development and testing of various reactor components for operation at the high temperatures to be encountered in the reactor. A study including experimental research and development in the field of pressurised heavy water reactors for electrical power production was under way at Savannah River.

Progress of construction of the Pressurised Water Reactor power station at Shippingport, Pennsylvania

(*To be continued*)

Personal and Business

Appointments

MR. A. F. BURKE has been appointed deputy chairman of de Havilland Holdings, Ltd.

THE BRISTOL AEROPLANE COMPANY, Ltd., has announced the appointment of Mr. J. R. Bradford as public relations officer.

MR. R. G. LEWIS has been appointed a director and general manager of Birwelco, Ltd., and Brown Fintube (Great Britain), Ltd.

MR. J. M. HALLETT, publicity department manager, Ferranti, Ltd., has been elected a member of the BEAMA publicity committee.

MR. H. P. POTTS, M.I.Mech.E., has been appointed a director of the Colchester Machinery Corporation, Ltd., Toronto, Montreal and Vancouver.

DR. K. J. WOOTTON, A.M.I.Mech.E., has been appointed deputy manager of the Atomic Energy Division, The General Electric Company, Ltd., Erith, Kent.

DR. W. P. MANSFIELD has been appointed director of research of the British Internal Combustion Engine Research Association, with effect from March 1, 1958.

MR. HUMPHREY WIGAN, a director of Amber Oils, Ltd., and Amber Pharmaceuticals, Ltd., has been appointed a director of the Amber Chemical Company, Ltd.

MR. J. W. PLOWMAN has been elected chairman of the British Valve Manufacturers' Association for the year 1957–58. The retiring chairman, Mr. N. P. Newman, has been elected vice-chairman.

MR. WILFRED LATHAM has been appointed resident Scandinavian liaison officer of Birfield Industries, Ltd. He will be responsible for the interests of the company in Sweden, Norway, Denmark and Finland.

THE CENTRAL ELECTRICITY GENERATING BOARD has announced the following appointments :—Mr. W. Usher, solicitor ; Mr. J. M. Drummond, chief financial officer, and Mr. S. S. Scott, chief personnel officer.

LLOYD'S REGISTER OF SHIPPING has announced that Mr. H. R. Gibbs, principal surveyor for Scotland, has resigned his appointment in order to take up a position as director and general manager of the Elderslie Dockyard of Barclay, Curle and Co., Ltd.

A. V. ROE CANADA, Ltd., has announced the following appointments :—Mr. Walter R. McLachlan, executive vice-president administration and co-ordination ; Mr. Fred T. Smye, executive vice-president aeronautical ; and Mr. A. C. Macdonald, executive vice-president industrial.

MR. BRIAN ARTHUR GOMM, assistant liaison executive of F. Perkins, Ltd., in India, has been appointed general manager of the South African subsidiary company, F. Perkins (S.A.) (Pty.), Ltd., in succession Mr. Norman Radley, director and general manager, who is leaving the company.

THE BRUSH GROUP, Ltd., announces the following appointments :—Mr. J. Calderwood has been appointed an executive director ; Mr. Maurice Tattersfield has been appointed an executive director of the Brush Group, Ltd., and remains a non-executive director of Brush Electrical Engineering Company, Ltd., Loughborough. Mr. B. L. Goodlett, M.I.C.E., M.I.Mech.E., M.I.E.E., has been appointed managing director of Brush Electrical Engineering Company, Ltd., and Mr. R. G. Hooker has been appointed director and general manager of that company.

THE SECRETARY OF STATE FOR SCOTLAND has appointed Mr. D. M. Brown, Rev. Ian Carmichael, Mr. W. H. M. Gill, Mr. T. Gilmour Bute, Bailie Mrs. Agnes S. Holway, Provost A. J. Mackenzie, Mr. J. D. Macrae, Councillor R. A. Raffan, Mr. W. D. Smith, Mr. R. E. Spain, Mr. J. Strachan, and Mr. F. W. Walker, to be members of the Electricity Consultative Council for the North of Scotland district. The size of the council has been increased in order to secure wider representation of the interests of consumers or potential consumers of electricity in the district.

Business Announcements

THE UNION CASTLE LINE has announced that Chief Engineer C. D. Mitchell has retired after fifty years' service with the sea-going staff.

RUSTON AND HORNSBY, Ltd., Lincoln, states that it has opened a new spares depot at 19, Great George's Street, Belfast (telephone, Belfast 25288).

E. H. JONES (MACHINE TOOLS), Ltd., states that it has been appointed sole distributor in the United Kingdom for the British built range of products of the Cincinnati Shaper Company, Ohio, U.S.A.

THE BRITISH TRANSPORT COMMISSION has announced that a party of seven Soviet railway experts, led by Mr. Beshchev, Minister of Railways of the U.S.S.R., is at present on a three week's tour of British Railways.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., states that the Radio Corporation of America has arranged to acquire technical information on the latest doppler navigation equipment from the company.

NEWTON AND BENNET, Ltd., and ALFORD AND ALDER (ENGINEERS), Ltd., have announced that the address of all companies in the group will be Marylands Avenue, Hemel Hempstead (telephone, Boxmoor 3800), as from December 2.

ELLIOTT-AUTOMATION, Ltd., states that it has purchased the entire share capital of Rotameter Manufacturing Company, Ltd., in consideration of the allotment of 269,000 ordinary shares of 5s. each in Elliott-Automation, Ltd.

C. H. JOHNSON (MACHINERY), Ltd., Adswood, Stockport, Cheshire, states that it has been appointed sole agent in Great Britain and Northern Ireland to manufacture under licence, Johnson-Vilver electro-mechanical lifting platforms.

LIQUID SYSTEMS, Ltd., Norwich Union House, Wellesley Road, Croydon, has signed an agreement with Schlegel Bro's, Stuttgart, for the exclusive selling agency in the United Kingdom and Eire of its waste oil re-refining and filtering plants.

FOUNDRY SERVICES, Ltd., announces that Foundry Services (Overseas), Ltd., will in future operate as Foundry Services International, Ltd. The board of directors will comprise : Dr. K. Strauss, Mr. E. Weiss, Dr. D. V. Atterton, Mr. G. E. Cobby, Mr. R. D. Hume, Mr. R. A. Miller and Mr. D. A. Patterson. Foundry Services, Ltd., will continue to operate as formerly but Mr. A. G. T. Chubb and Mr. J. C. Noon have joined its board of directors.

Miscellanea

CAR FERRY.—French Railways, Ltd., announces that the Dover-Calais car ferry " Compiegne," which has accommodation for 821 passengers and can carry 164 cars, will be put into service on May 30, 1958. The ship is being built by the Chantiers Reunis Loire-Normandie and has a length between perpendiculars of 357ft 7½in and will be propelled by two sixteen-cylinder S.E.M.T.-Pilstick diesel engines.

EARTH-MOVING EQUIPMENT.—We learn that the British version of the Euclid C.6 tractor, the prototype of which was illustrated last week on page 751, and is now in the United States accumulating operating time at the General Motors proving ground, has a speed of 8 m.p.h. and not, as stated, 7·5 m.p.h. When in production it will be distributed in this and most Commonwealth countries by John Blackwood Hodge and Co., Ltd.

GLASS.—A new colour film showing briefly some of the many interesting and varied processes involved in the manufacture of glass was shown before an invited audience in London on November 5. Made by Pilkington Brothers, Ltd., St. Helens, Lancs, it is the first of three films on the glass industry to be completed, and was shown at the Festival of Films in the Service of Industry held in Harrogate in October. The film is in 16mm size, but is not yet available on loan.

APPROVAL FOR HUNTERSTON NUCLEAR POWER STATION.—Plans for the Hunterston nuclear power station have been approved by the Secretary of State for Scotland. The approval covers the siting of buildings, the design and outside appearance of the main structures, and the access route : it accords with the views expressed by the Royal Fine Art Commission for Scotland and the Amenity Committee appointed under the Hydro-Electric Development (Scotland) Act, 1943. Ayr County Council was also consulted before approval was given.

DETERMINATION OF AIR IN HYDRAULIC FLUID.—There is now being manufactured and marketed by F. W. Bagget and Co., Ltd., 8, Temple Street, Wolverhampton, an instrument developed by the Mechanical Engineering Research Laboratory, East Kilbride, for the quick and accurate measurement of the air content of hydraulic oils. A sample of known volume is released suddenly into an evacuated chamber containing steel balls ; the oil spreads as a thin film over the large surface presented by the balls and the air is therefore quickly released. The total air content is found by measuring the initial and final pressures in the chamber ; by measuring the specific gravity of the sample, dissolved and entrained air may be distinguished.

BRIGHT NICKEL PLATING SOLUTION.—A bright nickel solution for plating in open-ended or immersed type barrels which was developed by Schering of Berlin, is now being marketed in this country by Roto-Finish, Ltd., 39, Park Street, London, W.1, under the name of " Rotor-Lux." This solution is stated to permit deposition of fully bright nickel plate in very short plating times, and to have a high throwing power which enables deep and narrow bores and cavities to be plated without difficulty. The high ductility of the deposit permits forming of work after plating, and parts can afterwards be chromium-plated in the ordinary way after thorough rinsing.

DECTRA TRIALS.—We are informed by the Decca Navigator Company, Ltd., that as part of the trials of the " Dectra " system for the North Atlantic a " Valiant " aircraft recently completed a flight from Boscombe Down to Montreal and back, navigating solely by this new system between 10 deg. west and Gander and using European and Canadian " Decca " coverage for the remainder of the flight. Tracking and ranging patterns are in operation, the former from two stations in Newfoundland and the latter being generated by synchronised transmissions from stations in Newfoundland and Scotland. Present information shows an error of only 2¼ miles off track after a flight of 1500 miles.

CYCLOIDAL VOITH-SCHNEIDER PROPULSION.—On November 19, Captain E. C. Goldsworthy and A. Betts Brown presented a paper entitled " Cycloidal Voith-Schneider Propulsion " before the Institution of Engineers and Shipbuilders in Scotland. The paper traces the development of the cycloidal propeller and describes recent applications, both as a main propeller and as an auxiliary manœuvring propeller. The Voith water tractor is discussed as an example of the use of cycloidal propulsion for towing purposes and there is reference to application of this form of propulsion to a fish factory ship designed for trawling over the stern. Several examples of auxiliary use are noted, in particular the Canadian ferry " Princess of Vancouver," in which a cycloidal propeller was installed in a transverse tunnel forward to give lateral thrust to assist in berthing the ship. Methods of control are examined and a section of the paper deals broadly with questions of design.

IMPROVED DRIVER'S BRAKE VALVE FOR ELECTRO-PNEUMATIC CONTROLLERS.—The standard rotary valve used on electro-pneumatic brake controllers on London Transport rolling stock requires regular lubrication and skilled maintenance, and experiments have been carried out with a new design of valve to reduce need for this maintenance. In this experiment three brake controllers have been fitted with four cam-operated poppet valves in place of the rotary valve, and the brake handle positions arranged identical with those of a standard controller. In the experimental controllers, developed by the Westinghouse Brake and Signal Company, Ltd., the port plate casting houses four rubber-seated poppet valves. These valves are mounted vertically and held upwards against their seats by spring pressure. The valve stems, which project from the air chamber of the casting, are sealed by synthetic rubber " O " rings. A circular face cam plate mounted above the valves and attached to the driver's brake valve spindle operates the valves through rockers which are fitted at the free end with rollers. During the year in which the three experimental brake valves have been in service, it has not been found necessary to carry out maintenance on any of them, and the wear on moving parts has been negligible.

IMPROVED FACILITIES AT SOUTHAMPTON AND HARTLEPOOLS DOCKS.—The British Transport Commission has authorised improvement schemes at Southampton and Hartlepools Docks at estimated costs of £410,000 and £564,750 respectively. At Southampton the works authorised comprise ten new electric quay cranes—nine for the New Docks and one for the Ocean Dock. Five of the cranes will be of 6/3-ton capacity and five of 3-ton, all with a working radius of 86ft. Improvements at No. 25 berth, Empress Dock, at which banana traffic is discharged by a system of elevators and conveyors, will include the reconstruction of two bays in the transit shed ; realignment of railway tracks, and improved facilities for the reception of passengers. The Hartlepools " A " and " C " jetties at Union Dock, which handle the bulk of the timber imported through the port, will be equipped with twelve new electric level-luffing cranes with a radius of 65ft. Two will be of 10/3-ton capacity and ten of 3-ton. The quays on the jetties will be paved flush in concrete, new crane tracks will be laid and railway lines repositioned. The west wall of Middleton Passage, the navigable channel between Central and Union Docks, will be rebuilt in steel sheet piling, and the width of the channel increased by 10ft to 67½ft.

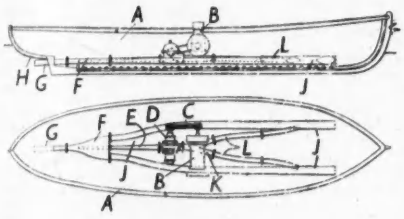
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

MARINE ENGINEERING

784,977. March 27, 1956.—THE PROPULSION OF WATER CRAFT, Robert Herrington Nichol, 110, Chertsey Road, Twickenham, Middlesex.

The invention has for its object to provide a simple and inexpensive propulsion system, which nevertheless operates with a high degree of mechanical efficiency. Referring to the drawing, amidships of the hull *A* is an internal combustion engine *B*, which drives through a belt and pulley system *C* the shaft of a centrifugal pump *D*, to the discharge end of



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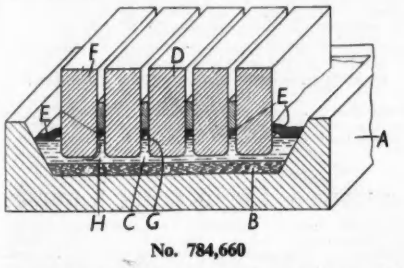
which is connected a pipe *E* running rearwardly to and terminating within a conical jet nozzle *F*, the narrow end of which is extended by a pipe *G* projecting through the hull beneath the counter *H* of the boat. On each side of the pipe *E* are connected to the wide end of the nozzle *F* the rear ends of a pair of wide ducts *J*, running along each side of the bottom of the boat to inlet openings on each side of the prow. As shown, these ducts may be slightly tapered so as to be of somewhat greater diameter at their forward than at their rearward ends. The suction side of the pump *D* is connected to a Y or V-shaped inlet pipe *K*, whose two branches are connected to suction pipes *L*, which also run to points near the prow of the boat where they branch into the ducts *J*, just short of their inlet ends. From the description it will be appreciated that when the pump is operating water is drawn from the openings at the forward end of the boat through the ducts *J*, and the suction pipes *L*, and after having a high velocity impressed on it by the pump, is discharged into the jet nozzle *F*. During its passage through the jet nozzle additional water is also drawn in by injector action from the water ducts *J* and is discharged through the nozzle pipe *G*, together with the water from the pump, so that a relatively large volume of water travelling at a relatively high velocity is discharged rearwardly from the stern of the vessel to serve as a reaction jet, which propels the boat. The speed of the boat can be controlled by controlling the speed of the engine and/or by a valve controlling the discharge of the pump.—*October* 23, 1957.

ELECTRICAL ENGINEERING

784,660. October 10, 1955.—ELECTROLYTIC CELL FOR PRODUCING ALUMINIUM OF HIGH PURITY, Vereinigte Aluminium-Werke Aktiengesellschaft, Am Nordbahnhof, Bonn-on-the-Rhine, Germany.

The invention relates to an electrolytic cell for producing aluminium of high purity by fusion electrolysis in which a melt at approximately 1000 deg. Cent. of alumina in cryolite is decomposed by electric direct



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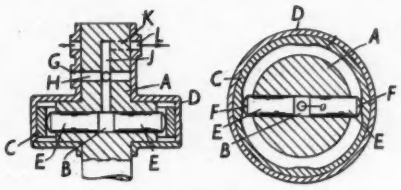
current. As shown in the drawing, *A* denotes the cathode, *B* deposited aluminium, *C* the melt, *D* the narrow individual anodes with small intermediate spaces, *E* the crust of solidified melt, *F* the packing between the anodes, and *G* the passages which are formed and in which the gases arising on the underside of the anodes as a result of the electrolytic process are collected and led off to the outside. The arrow *H* indicates the short path of the gases to the passages. Parts of the electrolytic furnace which are not essential to the invention, such as the current supply cables, the suspension of the anodes, and so on, have been omitted from the drawing. The drawing should also be regarded as a diagram in that the number of anode strips is in actual fact larger than shown, depending on the size of the furnace. It will be seen that the preburnt continuous anodes are disposed side by side, the individual anodes having a width of 200mm to a maximum of 700mm, a length of more than 1400mm, mutual spacing distances of less than 150mm, preferably 40mm to 50mm, the cell being intended for a current load of less than 10,000A per anode, preferably 5000A to 8000A.—*October* 16, 1957.

INTERNAL COMBUSTION ENGINES

784,589. May 13, 1955.—FUEL INJECTION PUMPS, C.A.V., Ltd., Warple Way, Acton, London, W.3. (*Inventor: Fraser Mackie Evans.*)

The invention relates to liquid fuel injection pumps comprising a body having at least one diametrical bore, a pair of reciprocatory plungers contained in the ends of the bore, and an annular cam acting on the outer ends of the plungers, reciprocation of the plungers being effected by relative rotation of the body and cam, and the fuel being supplied to and discharged from the central part of the bore between the inner ends of the plungers. Referring to the drawing, the body *A* of the injection pump has a single diametrical bore *B*, and is rotatable relatively to a fixed annular cam *C* contained in a housing *D*, the cam being angularly adjustable if desired. The inner periphery of the cam is shaped to impart inward movements to the two plungers *E* in the bore of the pump body, the outward movements of the plungers being effected by pressure of incoming liquid fuel supplied to the injection pump by a feed pump. The lobes of the cam are formed by four similar and



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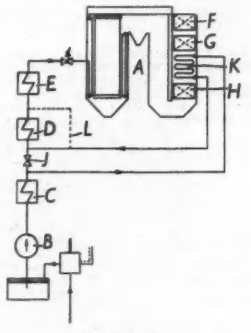
equi-spaced crests *F* with recesses as shown. The crests determine the inward positions of the plungers and the recesses determine the extent to which the plungers can move outwardly. The fuel is delivered from a feed pump through the inlet *G* and then passes through any of a number of radial ports *H* to the central bore *J* which communicates with the bore containing the plungers. With the inward movement of the plungers the fuel is discharged along the bore *J* to a single discharge port *K*, which, during rotation of the pump, successively passes each in turn of a number of outlets *L* leading to the different engine cylinders. The number of plunger bores in the rotary body, or the number of crests in the cam, may be varied according to the number of cylinders in the engine, provided that there is always an even number of cam crests.—*October* 9, 1957.

STEAM POWER PLANTS

785,062. April 6, 1955.—METHOD AND APPARATUS FOR PREHEATING FEED WATER, Siemens-Schuckertwerke Aktiengesellschaft, Berlin, and Werner-von-Siemens-strasse 50, 13a Erlangen, Germany.

The invention relates to a method and apparatus for preheating feed water in a high-pressure steam power plant operating on a regenerative cycle. Referring to the drawing, there is shown a forced flow boiler *A*, and the associated auxiliary plant, the boiler being adapted to generate steam at a temperature in the region of 550 deg. Cent. and at a pressure in the region of 300 atmospheres. The auxiliary plant comprises a feed pump *B*, regenerative heating stages *C*, *D* and *E* which operate at high pressure, and air preheaters *F*, *G* and *H*. By the term "regenerative heating stage" as used in the specification there is meant a stage where the feed water is heated with a portion of steam, which has been bled off from the steam turbine of the plant, in a manner known with steam power plants operating on a regenerative cycle. A shut-off valve *J* is located immediately between the high-pressure regenerative heating stages *C* and *D*. A flue gas preheater *K*, connected to both sides of the shut-off valve *J*, is located between the air preheaters *G* and *H*. The water, heated in the regenerative heating stage *C*, is fed, beyond this stage, to the flue gas preheater *K*. By the term "flue gas preheater" as used in the specification, is meant a preheater for the feed water, which preheater obtains its heat source from the flue gas, the feed water being heated by heat exchange with the flue gas. At the preheater *K* the water is further heated to a predetermined extent, for example, by 20 deg. Cent., and is then returned to a point located at or near the inlet to the stage *D*. In a modification only a part of the feed water leaving the stage *C* is fed to the flue gas preheater *K*, this part by-passing the stage *D* through a conduit *L* shown by a broken line, and being recombined with the main stream of feed water, at a point located beyond the outlet of the stage *D* and before the inlet to the stage *E*, after having been appropriately further heated. The conduit *L*, shown in a broken line, replaces that shown in an unbroken line, the stage *E* then becoming in effect the stage succeeding stage *C*



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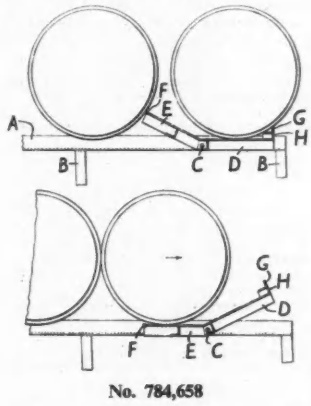
for such partial stream. The arrangement is thus adapted to extract heat from the flue gas by means of an additional preheater in order to lower the waste gas temperature without thereby appreciably influencing the efficiency of the regenerative cycle. Naturally, some reaction on the regenerative cycle will be unavoidable, because, while the feed water is at a higher temperature before a regenerative heating stage than when no additional heating surface is employed, the temperature difference in the regenerative heating stage is reduced. However, calculation shows that the gain in efficiency of the plant due to the provision of the addtional heater is greater than the reduction in the efficiency of the regenerative cycle. The reaction on the regenerative cycle becomes smaller in proportion as the extent to which the temperature in the regenerative heating stage can be increased.—*October* 23, 1957.

STORAGE DEVICES

784,658. September 27, 1955.—STORAGE DEVICES FOR CYLINDRICAL OBJECTS, R. H. Corbett and Co., Ltd., Hydrum Works, Burgess Hill, Sussex. (*Inventor: Robert Hugh Swan Corbett.*)

The invention relates to devices for storing cylindrical objects and provides a device which is particularly suitable for the storage of barrels and drums



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such as 40-gallon steel drums of oil. As shown in the drawing a rack is formed by two guide rails *A*, which have a gradient of between 1 in 20 and 1 in 30, and by a suitable supporting framework part of which is shown at *B*. A pin C passes through holes in the two guide rails and serves as a pivot for a gate. The gate has two parallel shallow V-shaped side members, one arm *D* of the V being longer than the other arm *E* and inclined to it at an angle of 150 deg. to 160 deg. The two shorter arms are connected by a positive stop member in the form of a bar *F*, which is welded to the upper edges of their free ends. The free ends of the longer arms *D* are connected by an upstanding stop member in the form of an angle piece *G*, which is mounted on corner pieces *H* and projects above the arms and the end of the rails. The longer arms *D* are arranged near the lower end of the rails, and, since this part of the gate is made heavier than the remainder, the gate normally occupies the position shown in the top view with the longer arms parallel to the rails and the shorter arms making an angle of 20 deg. to 30 deg. therewith. The automatic stowing of the drums is clearly shown in the lower view.—*October* 16, 1957.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Nov. 29.—COVENTRY BRANCH : Craven Arms, Coventry, Films on "Capacitors" and "Capacitors in Industry," 8.15 p.m.

Mon., Dec. 2.—LEEDS BRANCH : Great Northern Hotel, Leeds, "The Electronic Control of Variable Speed Drives," R. H. Stannard, 7.30 p.m. ★ NORTH-EAST LONDON BRANCH : Angel Hotel, Ilford, "Flameproof Installations," S. J. Emerson, 8 p.m. ★ SHEFFIELD BRANCH : Royal Victoria Station Hotel, Sheffield, "Normal Frequency Electric Furnaces," B. Evans, 7.30 p.m.

Tues., Dec. 3.—OXFORD, READING AND DISTRICTS BRANCH : The University, London Road, Reading, "Nuclear Reactors," 7.15 p.m.

Wed., Dec. 4.—NORTH LONDON BRANCH : "Queen's Head," 677, Green Lanes, Harringay, London, N.4, "Electrical Water Treatment," A. G. Freeborn, 7.45 p.m. ★ PRESTON BRANCH : R.A.F.A. Club, East View, Preston, "Design Processes for High-Speed Aircraft," B. O. Heath, 7.30 p.m.

Thurs., Dec. 5.—SOUTHAMPTON BRANCH : Pilgrim Room, Polygon Hotel, Southampton, "Closed Circuit Television and Future Developments," P. S. Carnt, 8 p.m. ★ BIRMINGHAM BRANCH : Chamber of Commerce, New Street, Birmingham, "Railway Electrification and Modernisation," J. A. Broughall, 7.30 p.m.

Fri., Dec. 6.—STOKE AND CREWE BRANCH : Crewe Arms Hotel, Crewe, "Modern Railway Signalling," F. W. Young, 7.30 p.m. ★ BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Broad Street, Bristol, "Earth Leakage Protection," J. A. Robbins, 8 p.m. ★ LIVERPOOL AND DISTRICT BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, Discussion on the Thirteenth Edition I.E.E. Regulations, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, Nov. 29.—SOUTH MIDLANDS SECTION : North Gloucestershire Technical College, Cheltenham, "Automatic Programming," P. M. Woodward, 7 p.m.

Wed., Dec. 4.—SOUTH WALES SECTION : Cardiff College of Technology and Commerce, Cathays Park, Cardiff, "Demonstrations on Aerial Circuits," H. V. Sims, 6.30 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Dec. 7.—Tudor Room, Caxton Hall, London, S.W.1, "The Physical Nature of the Surface of the Moon," G. Fielder, 6 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., Dec. 4.—SOUTHERN REGION : St. Ermin's Hotel, Westminster, London, S.W.1, "The Effectiveness of Instrumentation for Combustion and Process Work," R. Clare, 10.30 a.m.; "Nuclear Power Reactors," W. R. Wootton, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Tues., Dec. 3.—STOKE-ON-TRENT GROUP : North Stafford Hotel, Stoke-on-Trent, "The Lighting of Small Factories," J. S. McCulloch, 6 p.m.

Wed., Dec. 4.—NEWCASTLE UPON TYNE CENTRE : Lecture Theatre, Grey Hall, Department of Electrical Engineering, King's College, College Road, Newcastle upon Tyne, 1, "The Lighting of London Airport," J. G. Holmes, 6.15 p.m. ★ SWANSEA GROUP : Demonstration Theatre, South Wales Electricity Board, The Kingsway, Swansea, "Road Vehicle Lighting," K. J. Jones, 6.30 p.m.

Thurs., Dec. 5.—CARDIFF CENTRE : Demonstration Theatre, South Wales Electricity Board, The Hayes, Cardiff, "Road Vehicle Lighting," K. J. Jones, 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Dec. 3.—Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "The Impact of Automation on the Plant Engineer," J. F. Coales, 7 p.m.

Wed., Dec. 4.—LEICESTER BRANCH : Bell Hotel, Leicester, "The Research, Information and Training Activities of P.E.R.A.," D. D. Morgan, 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Dec. 3.—SLOUGH SECTION : Lecture Theatre, High Duty Alloys, Ltd., Slough, "Mechanisation on a Modest Scale," J. Bain, 7.30 p.m.

INSTITUTE OF FUEL

Wed., Dec. 4.—Institution of Civil Engineers, Great George Street, London, S.W.1, "The Manufacture of Town Gas from Liquid or Gaseous Fuels," E. J. Lawton, 5.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Fri., Dec. 6.—Grosvenor House, London, W.1, Annual Conversazione, 6.30 p.m.

INSTITUTE OF METALS

Wed., Dec. 4.—POWDER METALLURGY JOINT GROUP : Church House, Great Smith Street, London, S.W.1, Inaugural Meeting, "Recent Developments in Powder Metallurgy," I. Jenkins, 10.30 a.m.; "Developments in the Production and Quality of Metal Powders," 11.30 a.m.; Discussion, 2.15 p.m.

Thurs., Dec. 5.—Chemical Department, The University, Woodland Road, Bristol, "Design and Operation of Waste Heat Boilers in the Chemical Industry," W. Gregson, 6.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Dec. 4.—61, New Cavendish Street, London, W.1, "Recent Engine Developments in Relation to Fuels and Lubricants," D. Downs, 5.30 p.m.

INSTITUTE OF PHYSICS

Wed., Dec. 4.—MIDLAND BRANCH : Visit to Triplex Safety Glass, King's Norton, Birmingham, "Modern Safety Glass," A. J. Holland, 2.30 p.m.

Fri., Dec. 6.—LIVERPOOL AND NORTH WALES BRANCH : Department of Electrical Engineering, The University, Liverpool, "Cerenkov Radiation," J. V. Jelley, 7 p.m. ★ SOUTH WALES BRANCH : Physics Department, University College of South Wales and Monmouthshire, Cardiff, Branch Annual General Meeting, "Microwave Triodes," M. R. Gavin, 5.15 p.m. ★ NON-DESTRUCTIVE TESTING GROUP : 47, Belgrave Square, London, S.W.1, "Structural Imperfections in Metals and their Effect on Mechanical Properties," N. F. Mott, 6 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Dec. 5.—Junior Institution of Engineers, Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The Development of a Quick-Freezing Plant for Distant-Water Trawlers," G. C. Eddie, R. T. Hales and D. W. Higham, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Dec. 3.—EASTERN CENTRE : Golden Hind Hotel, Cambridge, "Two-Way Radio as an Aid to the Control of Goods and Passenger Vehicles," E. N. Farrar, 7 p.m. ★ WESTERN CENTRE : Royal Hotel, Bristol, "The Adaption of Commercial Vehicles for Use in a Special-Purpose Mixed Fleet," R. H. R. Hacker, 7 p.m.

Wed., Dec. 4.—EAST MIDLANDS CENTRE : Mechanics' Institute, Nottingham, "Rolls-Royce Diesel Power," 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Dec. 3.—LONDON BRANCH : Geological Society, Burlington House, London, W.1, "Shell Gasification Process and its Application to Industry," M. J. Gattiker, 5.30 p.m. ★ NORTH WESTERN BRANCH : Technical College, Birkenhead, "The Selection and Operation of Solvent Extraction Equipment," J. A. H. Walker, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Dec. 3.—Great George Street, Westminster, London, S.W.1, "Snow Clearance Problems in Switzerland," A. Knobel, 5.30 p.m.

Thurs., Dec. 5.—NORTH WESTERN ASSOCIATION : Engineers' Club, 17, Albert Square, Manchester, "Railway Diesel Traction and Associated Problems," A. B. Henderson, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Nov. 29.—SOUTHERN CENTRE : South Dorset Technical College, Weymouth, "Equivalent Circuits of Transistors and their Application," L. E. Jannson, 6.30 p.m.

Mon., Dec. 2.—EAST ANGLIAN SUB-CENTRE : Crown and Anchor Hotel, Ipswich, "Arc Suppression Coil Operation," L. B. S. Golds, 6 p.m. ★ NORTH EASTERN RADIO AND MEASUREMENTS GROUP : King's College, Newcastle upon Tyne, "Recent Uses of Ultrasonics in Investigating the Characteristics of Materials," J. Lamb, 6.15 p.m. ★ SOUTH MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, Joint Meeting with Radio and Measurements Group, Supply and Utilization Group, and Birmingham Centre of the I.P.O.E.E., "Electronic Control of Machine Tools," D. T. N. Williamson, 6 p.m.

Tues., Dec. 3.—CAMBRIDGE RADIO AND TELECOMMUNICATION GROUP : Cavendish Laboratory, Free School Lane, Cambridge, "The Mullard Radio Astronomy Observatory," M. Ryle, 8 p.m. ★ NORTH MIDLAND CENTRE : Central Electricity Authority, Yorkshire Division, 1, Whitehall Road, Leeds, "The Use of Transistors in Radio and Television," A. J. Biggs and E. Wolfendale, 6.30 p.m. ★ NORTH WESTERN CENTRE : Engineers' Club, 17, Albert Square, Manchester, "Cathodic Protection," L. B. Hobgen, K. A. Spencer and P. W. Heselgrave, 6.15 p.m. ★ SOUTH EAST SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, "Infra-Red Radiation," G. B. B. M. Sutherland, 7 p.m. ★ MEASUREMENT AND RADIO SECTIONS : Savoy Place, London, W.C.2, "Some Aspects of Half-Wave Magnetic Amplifiers," G. M. Ettinger ; "Some Transistor Input Stages for High-Gain D.C. Amplifiers" and "A Transistor High-Gain Chopper Type D.C. Amplifier," G. B. B. Chaplin and A. R. Owens, and "Dekatrons and Electro-Mechanical Registers Operated by Transistors," G. B. B. Chaplin and R. Williamson, 5.30 p.m.

Wed., Dec. 4.—LONDON GRADUATE AND STUDENT SECTION : Savoy Place, London, W.C.2, "Man/Machine Relationships," W. H. Dunkley, 6.30 p.m. ★ SHEFFIELD SUB-CENTRE : City Hall, Sheffield, "The Electrification of the British Railways," G. H. Fletcher, 7.30 p.m. ★ SOUTH-WEST SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Electrical Floor Warming," J. W. Moule and W. M. Stevenson, 7 p.m.

Thurs., Dec. 5.—NORTH MIDLAND CENTRE : Yorkshire Electricity Board, Ferensway, Hull, "Project Considerations for Diesel-Electric Traction," R. S. Wignall, 6.30 p.m. ★ LONDON BRANCH : Savoy Place, London, W.C.2, in conjunction with the British Nuclear Energy Conference, "Advanced Types of Power Reactors," J. V. Dunworth, 5.30 p.m.

Fri., Dec. 6.—SOUTH MIDLAND CENTRE : Town Hall, Birmingham, "The Electrification of the British Railways," G. H. Fletcher, 6 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Tues., Dec. 3.—EAST ANGLIA BRANCH : Assembly House, Norwich, "Soil Stabilisation," L. S. Blake, 6.30 p.m.

Fri., Dec. 6.—LONDON BRANCH : Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "Roads from the Beginning," E. J. R. Kennerell, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 29.—GENERAL MEETING IN CONJUNCTION WITH THE INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP : "Recent Developments in the Manufacture of Castings," J. L. Rice, R. W. Ruddle and P. A. Russell, 6 p.m.

Mon., Dec. 2.—N.E. BRANCH : Neville Hall, Westgate Road, Newcastle upon Tyne, "Vibration : A Survey of Industrial Applications," J. P. den Hartog, 6 p.m.

Tues., Dec. 3.—EASTERN BRANCH : Red Lion Hotel, Colchester, "Some Engineering Problems in Connection with the Industrial Application of Nuclear Energy," Sir Claude D. Gibb, 7.30 p.m. ★ N.E. BRANCH : Cleveland Institute, Corporation Road, Middlesbrough, "Vibration : A Survey of Industrial Applications," J. P. den Hartog, 6.15 p.m. ★ COVENTRY A.D. CENTRE : Leofric Hotel, Coventry, "An Approach to the Problem of Pressure Charging the Compression-Ignition Engine," D. W. Tryhorn, "The Design and Development of Small Radial Flow Turbo-Chargers," C. A. Judson and E. Kellett, 7.15 p.m. ★ N.W., A.D., CENTRE : Engineers' Club, Albert Square, Manchester, "Diesel Engine Lubricants : Their Selection and Utilisation, with particular reference to Oil Alkalinity," A. Dyson, L. J. Richards and K. R. Williams, 7.15 p.m.

Wed., Dec. 4.—N.W. BRANCH : Engineers' Club, Albert Square, Manchester, "Vibration : A Survey of Industrial Applications," J. P. den Hartog, 6.45 p.m. ★ LUTON A.D. CENTRE : Town Hall, Luton, "The Suspension of Internal Combustion Engines in Vehicles," M. Horovitz, 7.30 p.m.

Thurs., Dec. 5.—SCOTTISH BRANCH : Royal College of Science and Technology, Glasgow, "Vibration : A Survey of Industrial Applications," J. P. den Hartog, 7.30 p.m. ★ WESTERN A.D. CENTRE : Royal Hotel, Bristol, "Pneumatic Suspensions for Motor Vehicles," J. Sainsbury, 6.45 p.m. ★ E. MIDLANDS GRADUATES' SECTION : The University, Nottingham, "Photoelasticity," E. Ollerton, 7.15 p.m. ★ YORKSHIRE GRADUATES' SECTION : Grand Hotel, Sheffield, "Hydraulics in Steelworks," E. C. Brookes, 6.30 p.m.

Fri., Dec. 6.—INTERNAL COMBUSTION ENGINE GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Are Crankshaft Torsional Vibration Problems Things of the Past ?" 6.45 p.m. ★ SCOTTISH BRANCH : North British Hotel, Edinburgh, "Vibration : A Survey of Industrial Applications," J. P. den Hartog, 6.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Dec. 5.—10, Upper Belgrave Street, London, S.W.1, "Aspects of Propellers for the Royal Navy," the late R. W. L. Gawn (to be read by R. N. Newton), 4.45 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Mon., Dec. 2.—ORDINARY MEETING : Institution of Electrical Engineers, Savoy Place, London W.C.2, "Junction Transistors and their Application to Switching Circuits," R. V. Leedham, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Dec. 2.—LUTON SECTION : W. H. Allen, Sons and Co., Ltd., Bedford, "A New Approach to Quality Control," R. M. Belbin, 7.30 p.m.

Tues., Dec. 3.—LEICESTER SECTION : Grand Hotel, Leicester, "Lubricating Greases and Thin Film Lubrication," J. Spray, 7.30 p.m.

Wed., Dec. 4.—HALIFAX AND HUDDERSFIELD SECTION : White Swan Hotel, Halifax, "Increased Automation of Existing Production Lines," J. B. Jay, 7.30 p.m. ★ NOTTINGHAM SECTION : Victoria Station Hotel, Nottingham, "Copy Turning," W. A. Hawkins, 7 p.m. ★ DUNDEE SECTION : Royal Hotel, Union Street, Dundee, "The Production Engineer in the Management Team," J. Butler, 7.30 p.m. ★ LONDON SECTION : Power Samas Accounting Machines, Ltd., Aurelia Road, Croydon, Surrey, "Recent Developments in Plastics Moulding Techniques," A. Kingsman, 7 p.m. ★ WESTERN SECTION : Engineering Faculty, The University, Bristol, "The Emergence of Automation as an Evolutionary Process," J. A. Sargrove, 7.15 p.m.

Thurs., Dec. 5.—READING SECTION : Great Western Hotel, Reading, "Ultrasonic Machining," 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Dec. 2.—PRESTON SECTION : Bull and Royal Hotel, Church Street, Preston, "Moulds and Moulding," F. Skelton, 7.15 p.m.

Wed., Dec. 4.—S. WALES AND MONMOUTHSHIRE SECTION : King's Head Hotel, Newport, "What the Telecommunications Industry Requires from the Rubber and Plastics Industry," K. H. Whitlock, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Dec. 3.—NORTHERN COUNTIES BRANCH : Cleveland Scientific and Technical Institution, Middlesbrough, "Steelwork in Transit Shed 102, Southampton Docks," F. M. Bowen and B. E. S. Ranger, 6.30 p.m. ★ WALES AND MONMOUTHSHIRE BRANCH : S. Wales Institute of Engineers, Park Place, Cardiff, "Recent Thoughts on Structural Welding," A. V. Hooker, 6.30 p.m.

Wed., Dec. 4.—NORTHERN COUNTIES BRANCH : Neville Hall, Newcastle, "Steelwork in Transit Shed 102, Southampton Docks," F. M. Bowen and B. E. S. Ranger, 6.30 p.m.

Fri., Dec. 6.—S.W. COUNTIES BRANCH : Duke of Cornwall Hotel, Plymouth, "Some Unusual Structural Engineering Problems," C. E. Saunders, 6 p.m. ★ WESTERN COUNTIES BRANCH : Engineering Laboratories, The University, Bristol, "Tubular Structures," R. G. Taylor, 6 p.m.

INSTITUTION OF WATER ENGINEERS

Fri., Dec. 6.—WINTER GENERAL MEETING : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "The Waterworks Mechanical Engineer," J. Gardiner ; "The Pitsford Treatment Works of the Mid-Northamptonshire Water Board," J. W. Milne, 10 a.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 29.—Pepys House, 14, Rochester Row, Westminster London, S.W.1, Annual General Meeting, 7 p.m.

Wed., Dec. 4.—MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, Presidential Address, Rupert Morcom, 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Nov. 29.—Mining Institute, Newcastle upon Tyne, Annual General Meeting, "Service Performance Trials Carried Out in the North Atlantic on the S.S. 'Cairndhu,'" S. L. Smith and R. E. Clements, 6.15 p.m.

PLASTICS INSTITUTE

To-day, Nov. 29.—NORTH-WESTERN SECTION : Engineers' Club, Albert Square, Manchester, "The Machining and Finishing of Plastics," B. E. Terry, 6.45 p.m.

Wed., Dec. 4.—N.E. SECTION : Eldon Grill, Grey Street, Newcastle, "Reinforced Alkyd Moulding Material and its Application," G. Bell, 7 p.m.

REINFORCED CONCRETE ASSOCIATION

Mon., Dec. 2.—N.W. BRANCH : College of Technology, Sackville Street, Manchester, "An Industrial Building in Reinforced Concrete," M. B. Watson, 6.45 p.m.

Tues., Dec. 3.—N.W. BRANCH : Liverpool Engineering Society, The Temple, 24, Dale Street, Liverpool, "An Industrial Building in Reinforced Concrete," M. B. Watson, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Dec. 3.—4, Hamilton Place, London, W.1, "Some Techniques of Engine Testing under Simulated Icing Conditions," O. R. Ballard and P. J. Sharp, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Fri., Dec. 6.—12, Great George Street, London, S.W.1, "The Coal Mining (Subsidence) Act, 1957," E. Rutherford Young, 5.45 p.m.

ROYAL SOCIETY

To-day Nov. 29.—Burlington House, Piccadilly, London, W.1, Discussion on "Observations of the Russian Artificial Earth Satellite and Their Analysis," opened by H. S. W. Massey, 10.30 a.m.

Thurs., Dec. 5.—Burlington House, Piccadilly, London, W.1, Discussion on "Parity Conservation," opened by R. E. Peierls, 11 a.m.

ROYAL SOCIETY OF ARTS

Wed., Dec. 4.—John Adam Street, Adelphi, London, W.C.2, "Vitamins and the Scientist," F. Wokes, 2.30 p.m.

ROYAL SOCIETY OF HEALTH

Wed., Dec. 4.—ABERDARE SESSIONAL MEETING : Memorial Hall, Aberdare, "Measurement of Atmospheric Pollution and the Interpretation of Results," J. F. Jones, and "The Maintenance of Municipal Dwellings," H. W. C. Green, 10.30 a.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Tues., Dec. 3.—B.I.S.R.A., Hoyle Street, Sheffield, "The Physical Chemistry of Chemical Analysis," C. E. A. Shanahan, 7 p.m.

WOMEN'S ENGINEERING SOCIETY

Thurs., Dec. 5.—Central Electricity Authority, Winsley Street, London, W.1, "The Radio Telescope," 6.45 p.m.

X-RAY ENGINEERS ASSOCIATION OF GREAT BRITAIN, LTD.

To-day, Nov. 29.—Royal Horticultural Hall, London, S.W.1, in conjunction with the Nineteenth Annual Congress of the British Institute of Radiology, an Exhibition of X-Ray Apparatus.

Advanced Engineering Courses

Operational Research. UNIVERSITY OF BIRMINGHAM. Institute for Engineering Production, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course, Monday, November 25, to Friday, December 6. Fee £50.

Engineering and Metallurgical Aspects of Fatigue. BATTERSEA COLLEGE OF TECHNOLOGY, METALLURGY DEPARTMENT, Battersea Park Road, London, S.W.11. Course of ten lectures, Tuesdays, 7 to 9 p.m., commencing January 14, 1958. The course is designed to cover both modern industrial practice and recent theoretical developments. Fee £1.

Production Planning and Control. UNIVERSITY OF BIRMINGHAM, Institute for Engineering Production, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. From 9.30 a.m., Monday, December 9, to 4 p.m., Friday, December 20. Fee £50 (residential).